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WOOL

THE WORLD'S COMFORTER

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A SURVEY OF THE WOOL INDUSTRY FROM THE RAW MATERIAL TO THE FINISHED PRODUCT, INCLUDING DESCRIPTIONS OF MANUFACTURING AND MARKETING METHODS AND A DICTIONARY OF WOOL FABRICS

By
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TWELVE ILLUSTRATIONS.

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Introduction

IT is safe to say that, while wool is the oldest of all our textiles, the public knows less about it than about silk, cotton or linen.

Folks realize in a general way that woolen fibers come from the backs of sheep, yet they have little or no conception of the vast difference that exists between wool as it comes from sheep in various parts of the world, for example.

Most people think that wool suits or hats or socks are all alike, whereas there is often a very tremendous difference in those articles that may appear exactly alike. One may be of virgin wool and the other of wool that has been worked over many, many times.

Wool is the one textile for which no substitute has been found. We have fibre silk and materials made of various fibres that answer the purpose of cotton or linen, but NO material has been discovered that will take the place of wool.

So-called imitation wools may look, feel and appear like wool, but the body refuses to react to these in the same way it does to *real* wool.

Selling or buying woolen materials or products of any kind involves more than the sale of just the item. What the buyer wants is comfort or protection. The salesman who fails to realize this is missing a big opportunity.

That all may know the properties and kinds and types of woolens the DRY GOODS ECONOMIST has had prepared one of the most complete brief treatises on wool ever attempted. We doubt if any volume of its size gives in condensed form so much vital information about the oldest of our materials.

As is usual in Mr. Darby's writings, the book is free from technicalities so that it is easily understood by a layman.

Whether you buy or sell woolens you'll get greater pleasure from the handling of them if you are familiar with the facts contained in this book.

May the reading of it be a great pleasure.

ERNEST C. HASTINGS,
Managing Editor,
DRY GOODS ECONOMIST.

WOOL
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Chapter I
History of Wool

IT is probable that wool was the first fiber used by man for clothing. It is certain that wool shares with flax the distinction of being the most ancient of the textile fibers; but the origin of both of them goes so far back into prehistoric times that it is impossible to say which came first. In the beginning men used skins to clothe their bodies, and sheepskins no doubt were used widely for this purpose by primitive peoples. As far as we know, the pastoral stage always has preceded the agricultural stage in the development of civilization. Men lived nomadic lives and counted their wealth in flocks and herds for ages before they began to settle down and cultivate the earth. And unquestionably the woolly skins of sheep that died or were killed for food must have been deemed especially suitable for clothing.

Just when men first began to shear off the wool and to spin and weave it into cloth is another matter. They must have done it centuries before the dawn of recorded history; because the very earliest legends make reference to the fleeces of sheep, and sheep originally did not possess the woolly fleece we so inevitably associate with them now. Sheep in the beginning were covered with hair, and the wool was merely a slight soft down next the skin. Apparently it occurred to some prehistoric shepherd that sheep could be made to grow more of this wool by special breeding; and as a result of this experiment the woolly sheep was produced. It is very likely that the impetus to develop a woolly sheep came from previous experiments in spinning and weaving the fiber. That the production of wool for its own sake

goes back to the most ancient times we may infer from such early myths as that of Jason and the Golden Fleece.

Some idea of the antiquity of wool as a textile fiber may be gleaned from the fact that when the ruins of villages inhabited by the Swiss Lake Dwellers, in the Stone Age, were uncovered in 1853-54, fabrics made of wool were found there, and bodies wrapped in plaited woolen cloth have been found in the barrows of the early Britons. If we assume, as we plausibly may, that wool was used as a textile at a correspondingly early stage in the civilization of Asia, we can trace it back to the very childhood of mankind. Indeed Abel, the son of Adam, we are told, was a keeper of sheep, and whether we take the Bible literally or figuratively, this indication of the high antiquity of sheep raising is eloquent enough.

That the ancient Israelites were great sheep ranchers is well known. And that they used the wool for making cloth is suggested by many references to sheep-shearing made in the Bible. (For example, Genesis 38: 13, and 31: 19; Deuteronomy 15: 19; 1 Samuel 25: 4; 2 Kings, 3: 4.) Besides speaking frequently of the wool of sheep as a separate, valuable commodity, the Bible makes more direct references to its use as a textile fiber. The book of Proverbs, for example, says of the virtuous woman that she "seeketh wool and flax and worketh willingly with her hands." We find, too, that the priests were forbidden to wear garments of mixed wool and linen. This prohibition was evidently borrowed from the Egyptians, who forbade the wearing of woolen clothing by their priests.

Such a prohibition would indicate that woolen cloth was an article of such common use among the ancient Egyptians as not to be deemed suited for wear by the august servants of the gods; although one writer has suggested, with an apparent flippancy which may convey a real truth, that perhaps the Egyptian linen manufacturers had a pull with the Government. As an instance that this latter surmise may not be so absurd as it sounds, the writer cites the fact that Charles the Second of England, with the express object of promoting the use of woolen cloth in his realm, decreed that all dead persons must be wrapped in woolen shrouds.

HERE IS A SCENE FROM THE NEW ENGLAND HILLS. THE SHEEP ARE BEING RELIEVED OF THEIR FLEECE BY SHEARERS WORKING WITH HAND SHEARS. NOTE HOW THE OLD FELLOW IN THE FOREGROUND HOLDS THE SHEEP DOWN DURING THE OPERATION. ON LARGE RANCHES, POWER SHEARS ARE USED

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But in any case, even if the Egyptian linen manufacturers were forced to use their influence with the Government, it merely goes to show that they were having a hard time with the competition of woolens. We have evidence to prove that the Egyptians wore both woolen and linen garments fully 3000 years before the opening of the Christian era, and it is likely that the beginning of woolen spinning and weaving among them antedated that time by many centuries.

Coming down to later times we find from Homer (about 850 B. C.) that wool clothing was familiar to the most ancient Greeks. Evidently it was linen that Penelope was spinning while she held off her suitors until Ulysses could get back to her; but the familiar practice of spinning and weaving among the Greeks of that period is enough to suggest that they must have been making woolen cloth for a long time, as they were a pastoral people. Apparently they got the textile arts from the Babylonians. Herodotus tells us that the Babylonians wore woolen tunics, and Tertullian says: "From the beginning the Milesians were employed in shearing sheep, the Seres in spinning the product of trees, the Tyrians in dyeing, the Phrygians in embroidery and the Babylonians in weaving."

Nobody who has read much in the history and legend of ancient Rome can escape the impression that the Roman matron did practically nothing but spin and weave from morning to night. Every time we catch a glimpse of her she is sitting at her distaff or sending her shuttle merrily "flashing through the loom." It is quite probable that most of the clothing worn by the ancient Romans was made of wool; for even in later times, when Rome began to grow rich, linen still was considered something of a luxury. Sheep raising was carried on extensively in the country around Rome, and when we get down to the Augustan age we begin to find evidence that the Romans devoted considerable attention to the breeding of sheep.

In fact, the finest wool-bearing sheep of our own times are indirect descendants of Roman breeds. About two hundred years before the birth of Christ the Romans had developed a breed of Tarentine sheep, which had valuable wool-bearing properties. These sheep were brown or black. The Arabs of Northern Africa in the meantime had devel-

oped a good wool-bearing sheep which was pure white. Undoubtedly the Arabs had bred sheep for their wool at a much earlier period than the Romans, inheriting the custom from the pastoral tribes that wandered the plains of Asia in prehistoric times. But the Romans apparently were the first European people to devote serious attention to sheep-breeding.

In the first century A. D., a Spanish farmer crossed some Tarentine ewes with African rams, and the result of this cross was the famous Spanish merino, the ancestor of the finest wool-bearing sheep of our day. For many centuries Spain was the great wool-producing country of Europe. The famous merino stock was renewed there with Barbary rams imported by Pedro IV in the 14th century and by Cardinal Ximenes in the 16th century. But from about the 10th century on Spain had a dangerous rival in England, and by the 13th century England was unquestionably the greatest wool producing country in Europe. The reason for this is difficult to understand, as the English sheep could scarcely have been equal to the Spanish merino. But possibly the English wool was cheaper.

It is difficult to ascertain when the rearing of sheep for their wool first began in England. Wool was used for clothing in that country before the Roman conquest, and the Romans manufactured woolen clothing there on a considerable scale for the use of their legionaries. But there is no documentary reference to native wool. A document of the year 712 mentions the price of sheep; but gives no inkling of whether the sheep were valued for their wool or their mutton. But by the 10th century we find English wool a most important article of commerce. In that century (the year 961, to be precise), Count Baldwin III established a woolen manufacturing industry at Ghent and wool markets at Ypres and Bruges, and for fully three centuries thereafter Flanders and Brabant were the great woolen manufacturing centers of Europe. Most of their raw material was derived from England.

But beginning about the reign of Henry I, England began to develop a woolen industry of her own, and this industry was promoted most energetically by Edward III, who, among other measures for the

benefit of the English industry, prohibited the export of wool from England. From the reign of Edward III to that of Elizabeth the prohibition on the export of wool continued. It was lifted during the reign of Elizabeth; but was again put into effect in 1660 and continued until 1825. The measures taken to promote the woolen manufacturing industry in England also served to promote the sheep-breeding industry, and by the opening of the 19th century there were estimated to be about 30,000,000 sheep in England. Many of the English breeds, as we shall see in a later chapter, were good wool-bearing sheep, although none of them could quite compare with the merino.

During the centuries when England shut down on the export of wool, Spain was the main provider of raw material to the continental woolen industry until the Peninsular War. France, Germany and Austria also produced some wools of fine quality. But Spain maintained her pre-eminence chiefly by virtue of the merino, which was heavily protected by laws forbidding under heavy penalties the export of merino sheep. Some of these sheep, however, trickled out into other countries as royal presents to reigning sovereigns. In this way Louis XIV of France got some which were the progenitors of the famous Rambouillet merinos. Others went to Germany and Austria, the former resulting in the Saxony merino, probably the finest of all wool-bearing sheep. Still others went to Holland, which sent them to the Cape of Good Hope after the Dutch settled that colony, and laid the foundation for the great wool-raising industry of South Africa. Some merinos were brought also from Spain to England—by smugglers, it is said.

In the meantime, an important wool growing industry had been developing in the New World. In South America the use of wool as a textile fiber goes back to very ancient times. The Incas of Peru wove cloths of wool, and wool cloths were found also in Mexico by the first explorers of that country. The beginning of the North American wool growing industry, however, may be traced to the landing of English sheep at Jamestown, Va., in 1609. James I, who was interested in promoting so many things, encouraged wool growing in the Colonies, and the industry was further encouraged by subsequent colonial gov-

ernors. In the early 18th century, Jamaica, Maryland and Virginia were exporting wool to England.

But the greater profits in tobacco and cotton interfered with the promotion of sheep raising in the South on a large scale, while in New England the climate was not particularly favorable, as it made pasturing difficult or impossible in winter time. Nevertheless, considerable attention was paid to sheep breeding in this country after the Revolution and during the early years of the 19th century, and Vermont especially became famous for the breeding of fine sheep. Between 1801 and 1812 merino sheep were introduced by William Davis, Col. David Humphreys and others. From these have developed a fine American type known as delaine. Finally the opening up of the West provided large areas suitable for sheep raising, and made the United States one of the important wool producing countries of the world.

But the 19th century, which marked the growth of the United States and the decline of Europe as wool-producing regions, saw both of them rapidly overshadowed by Australasia, which is now by all odds the greatest wool producing area in the world. The foundation of the Australian sheep raising industry seems to have been laid by Capt. John MacArthur of the British Army, who brought some merinos there from the Cape in the beginning of the 19th century. Later a considerable number of Rambouillet rams were brought from France and crossed with the other merino stocks. Merinos were brought to Australia also from England, Saxony and the United States. In New Zealand and in South America the sheep raising industry began somewhat as it did in Australia, with the importation of merinos from other countries; but, unlike Australia, both New Zealand and South America gradually began to devote more and more attention to the raising of mutton or cross-bred sheep, and while they are still important wool-producing countries, they supply a comparatively small proportion of fine wools.

Chapter II

History of Wool Manufacture

As mentioned in the preceding chapter, wool was first made into cloth ages before the beginning of recorded history. It is assumed that primitive men made woolen cloth by felting the wool before the arts of spinning and weaving were discovered. There is no means of knowing that they did this, except by analogy with primitive people of our time, such as the Polynesians, who make cloth from vegetable fibers in this way. But the pulpy nature of vegetable fibers may have suggested such a method of treatment as an alternative to the more laborious work of spinning and weaving, and it is to be doubted if woolen cloth was first made in such a manner.

It is much more likely that the art of weaving, in its most elementary form, was practised long before men abandoned the use of animal skins for clothing, or perhaps even before they adopted clothing at all. No doubt it began with the first crude attempts of primitive women to weave twigs into some kind of object, with no other idea, probably, than a mere childish curiosity as to what the result would be, or an equally childish desire to keep their hands employed during the long hours when the men were away on the chase.

After they had succeeded in making baskets and similar articles, it probably occurred to some bright cave woman that clothing might be made by weaving some soft material like wool. To do this it would be necessary to twist tufts of wool into long strands. Thus we have the beginning of spinning. And as the strands of wool were not stiff like twigs, it would be necessary to have a certain number of them stretched taut between poles or something in order to weave the fabric. Thus we had the first loom.

All this is surmise, of course, but it is probable that the arts of spinning and weaving began in some such way. When we come to the earliest mythological and historical records we find the arts of spinning and weaving mentioned so frequently as to suggest that they had been in existence for long ages and had been developed to

a fairly advanced stage. The Egyptians attribute the invention of weaving to the goddess Isis, and they themselves were generally credited by other ancient peoples with having been the inventors of weaving. This, however, was due largely to the deep impression made by Egyptian civilization on the ancient world, particularly the Greeks. It is more probable that the Egyptians developed the art of weaving to a higher degree than any other people, for they were excellent craftsmen, and that they borrowed some of their best ideas, as was their custom, from the Assyrians.

In the Bible we find Job complaining that the days of his life fly past as quickly as the shuttle through the loom—a very familiar complaint. It suggests, however, that the weavers of his time must have had considerable skill. To judge by the pictures of ancient Egyptian looms, most of the skill must have been in the fingers of the operatives. But the imperfection of their looms did not prevent them from weaving beautiful fabrics, no more than it prevented the Hindus from weaving their exquisitely fine Dacca muslins on looms of an equally primitive type. Later, Babylon became the great center of trade in woolen cloths, and its people are said by Tertullian to have surpassed all other people in weaving, just as the people of Tyre surpassed all others in the art of dyeing. Still later the trade supremacy passed to Carthage.

It would be interesting to know whether those ancient trading nations had anything remotely approaching the beginnings of a factory system. We consider it likely that they had. The surpassing skill of the Egyptian and Babylonian weavers is convincing proof that they were highly trained craftsmen, and it is altogether likely that they were slaves employed in numbers by wealthy merchants. It is probable that they were housed under one roof by their masters, with women and children who did the picking, carding and spinning, and thus constituted what might be called a factory in embryo. Among more pastoral peoples, such as the Greeks and Hebrews, the spinning and weaving were done in the home, and women of the highest rank busied themselves with making clothing for their households. And it is a curious thing that the textile industry, until comparatively

recent times, developed along the lines of a household craft rather than along the lines of the primitive factory system.

Both systems seem to have existed in ancient Rome. The Roman matrons of the patrician class were very industrious women and proud of their skill in spinning and weaving. On their great estates they maintained large numbers of male and female slaves, some of whom they instructed in the textile arts, so that every estate had a sort of private textile factory which supplied clothing for the family and its servants. There was also in Rome and other cities of the empire a class of professional weavers, called *textores*, who in some cases, perhaps, were freemen and practised their craft independently, although in most cases probably they were slaves. The usual dress of the Romans was made of wool, and even as late as Cæsar's time linen was something of a luxury, while silk was decidedly so. There was the *toga densa* or *hirta* (thick or hairy toga) worn in the winter time, and the *toga trita* or *rasa* (thin or smooth toga) worn in summer. The former obviously was made of a heavy, napped, woolen cloth, and the latter of a light material similar to worsted.

It is not apparent, however, that the Romans developed to any great extent the textile arts, or any other arts except those of war. The important centers of the textile industry continued to be in Asia and North Africa, although in the declining years of the Roman Empire there were considerable textile manufactures in Constantinople and other Greek cities. During the early centuries of the Christian era the finest woolen stuffs were made in Bagdad, Damascus and other cities of the Saracenic Empire, while the barbarians were overrunning Europe, extinguishing the torch of civilization which the Romans had kindled.

In the textile arts, as in all other respects, this torch was rekindled by Venice, Florence and the other great cities of the Italian Renaissance. Venice it was that brought woolen manufacture back to Europe. Even before this time, it is true, there was a flourishing woolen industry in Spain. The industry had been introduced there at a very early age by the Carthagenians, and was re-introduced in the 8th century by the Saracens, who were noted for the production

of beautiful fabrics. But Moorish Spain was only geographically a part of Europe. It was really a part of the Saracenic Empire, and it did not serve as a carrier of the textile arts to other European countries. In the Middle Ages, Barcelona had become the seat of an important woolen industry and its products were far-famed. But after the discovery of the New World the attention of the Spaniards was turned to gold and the more prosaic textile industries began to decline.

In Venice, Florence, Padua and other Italian cities, however, the woolen industry flourished apace. Venice imported weavers from Constantinople and the cities of the Levant, and became not only a great woolen manufacturing center, but a great cloth market. In Florence, we are told, wool manufacturing was established about the year 1250 by friars of the Order of St. Michael of Alexandria, and soon grew to large proportions. Villani, in his "History of Florence," says that in the year 1340 there were over 200 wool manufacturing establishments there, supporting about 30,000 people.

In the medieval Italian cities they had the guild system, which was more a development of the household craft than of the primitive factory system. Instead of being slaves working for a master, the weavers of the Middle Ages were independent craftsmen, who were very proud of their skill and put on considerable airs. A master weaver conducted his business in his own home, with the aid of his family and apprentices, and he had his yarn spun for him by women and children either on his own premises or in their homes. An apprentice could rise to the dignity of a master weaver on his own account after he had served a certain number of years and passed the tests of the guild, which were very strict. This system, with variations, continued until the beginning of the industrial revolution.

From Italy, the woolen industry spread to the Netherlands, where it is said to have been established by Count Baldwin III about the year 960 or 961. For centuries the industry flourished in Flanders, Brabant and Hainault, and supplied most of Europe with clothing. Bruges was the great woolen market until the 16th century, when it began to be eclipsed by the rise of Antwerp. Ghent and Louvain

WOOL PILED HIGH IN A WAREHOUSE IN BUENOS AIRES, ONE OF THE WORLD'S IMPORTANT WOOL CENTERS. SOUTH AMERICAN WOOL GENERALLY IS NOT AS HIGH GRADE AS AUSTRALIAN OR EUROPEAN WOOL, BUT ADDS AN IMPORTANT QUANTITY TO THE WORLD'S PRODUCTION

also were important manufacturing cities. It is said that in the year 1305 Louvain had 4000 weaving establishments, employing 150,000 journeymen weavers; but this doesn't sound at all probable. In the 14th century the woolen industry of the Netherlands began to decline, and the religious persecutions of the 16th century practically ruined the industry. In the 16th and 17th centuries the chief manufacturing centers were Leyden, Haarlem and Amsterdam. France, owing perhaps to continued wars, was very late in taking up woolen manufacture, being content to get her supplies from the Netherlands. It was not until the reign of Henry of Navarre that the industry began to be developed in an important way. Subsequently, the province of Languedoc, particularly the city of Nismes, became famous for fine woolen cloths.

In England, the Romans are supposed to have taught the Britons how to make woolens. In any case, they had a factory at Winchester, which made clothing for their legionaries, and this may be said, perhaps, to have been the beginning of the industry in England. Then came the invading Angles and Saxons, who were relatively barbarians and certainly had no organized industry of any kind. But they practised spinning and weaving in their homes.

The real beginning of the woolen industry in England, however, was laid by the first immigrant Flemish weavers. Some of them are said to have come over with William the Conqueror; but this is by no means certain. A considerable number of weavers were driven from Flanders by floods, and settled in England in the reign of Henry I. That they came in considerable numbers is proved by the fact that during the reign of Henry I and his successor, Stephen, several guilds of weavers were incorporated. Their principal headquarters was the city of Norwich, which remained for centuries the chief woolen manufacturing center in England. Some of them settled in Worstead, in Norfolk, and specialized in fine cloths, which became known as worsteds, after the city in which they were made.

The wars which disturbed the reigns of John and Henry III, brought decay to the English woolen industry; but it began to revive during the reigns of Edward I and II and was put on such a flourish-

ing basis by Edward III that often he is given credit for having founded the industry in England. But Edward, like many another man, gets a lot of credit which ought by right to go to his wife. She was Philippa, daughter of the Earl of Hainault, and being a Netherlander, she had grown up with the woolen industry, so to speak. At her suggestion and through her influence Edward III brought over crowds of Flemish weavers, dyers and fullers, whom he encouraged and protected in every possible way. During his reign the industry spread all over the kingdom.

After Edward's death the woolen industry languished until the reign of Henry VI, who took some steps to promote it, among them being the establishment of a system of inspection to prevent short measuring and misrepresentation of goods, a practice which had become distressingly common among the honest craftsmen of the time. Henry VII, who was a good business man, brought over more weavers from Flanders and encouraged the industry energetically; but Henry VIII, who was not a good business man and had other things to think of, paid little attention to it, and the industry began to decline again. It revived in the reign of Elizabeth, when there was a further immigration of weavers, following religious persecution in the Netherlands.

Thereafter, with various ups and downs, it continued to flourish until the 18th century, when the invention of the fly shuttle, the spinning jenny, the mule and the power loom gave it a tremendous impetus. After the discovery of steam power the industry shifted more and more to the North, where coal was handy. For many generations before this there had been considerable woolen manufacturing in Yorkshire and other Northern counties; but after the application of steam power the North began to thrive industrially at the expense of the rest of the country, and during the 19th century the woolen manufacturing industry became concentrated chiefly in the West Riding of Yorkshire.

Credit for founding the industry in America seems to belong to a number of Yorkshire families who settled at Rowley, Mass., about 1638, and built a fulling mill there in 1643, making cloths from both "cotton wool" and "sheep's wool." No doubt the very first immigrants

spun and wove woolen cloths in their homes as soon as they could get wool to spin and weave them with. As early as 1639 there is record of home-made cloth in the records of the Probate Court of Massachusetts, and the Massachusetts Bay Colony offered bounties for woolen cloth made from home-grown wool.

Most of the Colonial legislatures, as a matter of fact, did everything possible to promote the woolen industry, and by the middle of the 17th century it was well established. In order to promote sheep raising, an act was passed in 1654 prohibiting the importation of wool from England. By 1699 the industry had grown to such proportions that the British Parliament, fearful of the effect of such competition on the home industry, prohibited the export of woolen manufactures from the Colonies. By that time there were woolen mills—with hand machinery, of course—at Roxbury, Watertown, Andover, Ipswich, Barnstable and many other New England towns. In 1695 a worsted mill was established by John Cornish at Boston.

During the first half of the 18th century woolen manufacture continued to flourish in the Colonies, although largely as a cottage industry. This in spite of the fact that, while the Colonial legislatures had not been slow in promoting the woolen industry, their most energetic efforts had been devoted to the establishment of a linen industry. As a sort of testimonial to these combined efforts the most characteristic and widely used cloth of the period was the linsey woolsey, a fabric with a linen warp and wool filling.

After the Revolution it took fresh life, not only in New England but in Pennsylvania, where it had been introduced by the early Quaker and German settlers. It is said that there were twelve fulling mills in Philadelphia in 1760. During the Revolution, Philadelphia made clothes for the Continental Army, and the industry was encouraged there by the patriots. By 1810 there were three woolen mills in Philadelphia and one in Germantown—that is, real woolen mills conducting all the processes in the manufacture of cloth. The first woolen mill of this kind in America seems to have been one established at Hartford, Conn., in 1788, and known as the Hartford Woolen Manufactory. The first woolen mill worked by power machinery is said

to have been built at Newburyport, Mass., in 1794, under the direction of John and Arthur Scholfield, who came to Boston from Saddleworth, Yorkshire. The former built a mill at Montville, Conn., in 1799, and his brother built one at Pittsfield, Mass., in 1800. From this time on, the industry developed gradually until 1845, when the city of Lawrence was founded and the career of the great American woolen industry, as we know it now, really began.

Chapter III

The Wool-Bearing Sheep

IT is difficult to define the difference between wool and hair. In fact, many authorities maintain that there is no real difference between them, and that wool is simply a variety of hair. Certainly, it is impossible to say exactly at what point an animal fiber ceases to be hair and becomes wool. On some wild or neglected sheep, for example, the wool is as much like hair as the hair of some other animals is like wool.

However, wool may be differentiated from hair by the fact that the latter is straight and smooth, while the former is wavy or kinky and is covered with minute serratures, or saw-like teeth, varying between 1200 and 3000 to the inch. It is these characteristics of wool which give it such value for textile purposes. The waviness of the fibers gives them elasticity and their serrated surface causes them to adhere closely to one another, so that they mat or felt readily.

Chemically, wool is composed of carbon, hydrogen, nitrogen, oxygen and sulphur. The proportions of these substances vary in different kinds of wool, some wools having a high carbon content, some a high nitrogen content, and so forth. Because of its chemical content wool will resist the action of most acids, but will dissolve readily in a strong alkali. It is very easy, therefore, to detect the proportion of wool in a cotton-mixed fabric, for instance, by immersing the fabric in a solution of caustic soda, which will dissolve the wool but leave the cotton intact.

Physically, wool, like hair, is a hollow tube, the medulla or hollow core being ⅛ to ¼ the total diameter of the fiber. This is a great advantage in dyeing, since the coloring matter enters the ends of the fiber, filling up the hollow core and showing through the transparent outer surface like colored liquid through a glass bottle. Were it not for this advantage, wool, owing to its hard, scaly surface, would be very difficult to dye satisfactorily.

The quality of wool depends upon a number of conditions, the chief

of which, perhaps, is the variety of sheep from which it is taken. It can readily be understood that, among the hundreds of millions of wild and domesticated sheep raised in all parts of the world under all sorts of climatic conditions, with countless differences in care and breeding, the varieties of wool produced are practically without limit. All these varieties, it is thought, derive from a few original classes of hairy sheep and have been multiplied beyond count by interbreeding through thousands of years. They may be divided roughly into wild sheep and domesticated sheep. The former, which are still to be found in large numbers in South Africa, South America, India, Thibet, our own Rocky Mountains and other localities, may be passed over without comment, as they are of no importance from a commercial point of view.

Domesticated sheep of all varieties, however, produce wool of more or less value for commercial purposes. All of them derive originally, it is presumed, from the moufflon, a rough-haired sheep which roamed the plains of central Asia in prehistoric times and was probably the first animal domesticated by man. Presumably it was a black or brown animal with a thick covering of hair and a light down of wool next the skin. It is quite likely that the development of the woolly coating on sheep happened at first accidentally through domestication and the inbreeding of domesticated animals; for the tendency of sheep which are neglected and allowed to run wild is to revert to the hairy type. Later, sheep were bred expressly for their wool, and we have evidence that efforts were made to breed white sheep even as early as Biblical times.

At the beginning of the Christian era there had been developed in Asia and Africa a fine, white, wool-bearing sheep, and the crossing of this variety with Tarentine sheep by a Spanish farmer, as noted in a previous chapter, resulted in the development of the Spanish merino, the ancestor of our finest wool-bearing sheep. At present the merino variety is cultivated in all the sheep-raising countries of the world. Naturally, it has been influenced by climatic and other conditions in different countries, so that there are many different kinds of pure merinos. For example, the Spanish merino introduced into Germany

THE FLEECE CONTAINS SEVERAL QUALITIES OF WOOL, ADAPTED FOR DIFFERENT PURPOSES. THESE MEN ARE SORTING THEM, TEARING THE FLEECES APART

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developed into the Saxony and Silesian merino, which produces the very finest wool in the world. Saxony merinos have been introduced into the United States and other countries, and mixed with other merinos or other varieties.

Similarly, the Spanish merino introduced into France developed into the Rambouillet type, which has been specially popular in the United States. Merinos also have been introduced into the United States directly from Spain. So, we have in this country merino sheep descended from French, German and Spanish types, and modified by climatic conditions in different parts of the country and by different methods of care and breeding. In Australia, to give another example, merinos have been introduced at various times from South Africa, England, the United States, Germany and France. These, in turn, have been modified by local conditions, so that there are three distinct types of Australian pure merino, varying from a small sheep with very fine wool to a large sheep with comparatively coarse wool.

In general, the merino is a small sheep, very thickly covered with fine, crimpy wool. Its short legs and its thick wool coating, which covers practically all its body except its feet and its snout, gives it rather a funny appearance, somewhat resembling those little woolly lapdogs which women carry around with them. The fiber is very fine and of medium staple, varying between two and four inches. It contains more serratures or scales to the inch than other varieties and this, together with its fineness, makes it specially valuable for the production of fine fabrics. It is not so lustrous as the coarser wools of other varieties.

Next to the merino, the most important wool-bearing sheep are the so-called long-wool sheep, which are of English origin. As the name indicates, the chief characteristic of these sheep is a wool of long staple, ranging from four to twelve inches. The wool, as a rule is coarse and highly lustrous. Because of its coarseness it is not desirable for most kinds of fabrics. But the weight and length of their fleece, and the fact that they are suited for mutton as well as for wool, makes the long-wool sheep very desirable for crossing with merinos, and they are used principally for this purpose. The

best-known varieties of long-wool sheep are the Leicester, Lincoln, Cotswold and Romney Marsh.

Leicester sheep are considered to be the oldest of the English long-wool breeds. They produce a clean wool of good quality and exceptional luster. Because of its small head, the Leicester is especially suitable for crossing with small-framed merino ewes, and the result is one of the finest of cross-bred wools. It is also used to a considerable extent for crossing with other breeds, especially with Lincoln and Romney Marsh sheep. The wool of the pure Leicester is very long in staple, often over twelve inches, but it is too coarse for general use, except in braids, linings and certain lustrous dress goods.

The Lincoln is a large-framed sheep producing a very heavy fleece of long-staple wool. The average Lincoln will yield from 12 to 15 pounds of wool. This wool is slightly less lustrous than that of the Leicester, and somewhat coarser. The Lincoln is excellent for crossing with pure merino and cross-bred merino ewes, and is used extensively for this purpose, especially in South America and the western United States.

Cotswold and Romney Marsh sheep yield what are frequently referred to as semi-luster wools, that is, wools which are not so lustrous as those from the Lincoln or Leicester breeds, but more lustrous than merinos. The Cotswold bears a general resemblance to the Leicester, and has been found useful for crossing with merino ewes. It is perhaps the favorite breed for this purpose on the western ranges of the United States. Crossed with the merino, it produces an abundance of good wool and fairly good mutton. The Romney Marsh is a hardier breed, especially suited to a wet climate and to poor country. Crossed with the merino, it produces a hardy sheep with a bright, fine, long-staple wool. It is little known in the United States, but is used a good deal for crossing with merinos in South America and New Zealand. The latter country also uses Leicester sheep to a considerable extent for crossing with merinos.

Both in South America and New Zealand, and on an increasing scale in the United States, sheep are being bred more and more for mutton, and this has led to the frequent crossing of merino and

long-wool sheep with the mutton varieties. The mutton sheep as a class are small and easily fattened. They run to fat rather than to wool, and yield a light fleece of fairly fine, soft, short-staple wool. Since both wool and mutton have a commercial value, it is a common practice to cross the mutton sheep with other varieties, especially long-wool breeds. Probably the best of these mutton sheep is the Shropshire, which produces a thick fleece of tolerably good wool, as well as excellent mutton. For this reason, and because it needs comparatively little care, it is the most useful type for the general farmer. In Australia it is used often for crossing with small-framed merinos.

As a mutton producer, the Southdown sheep is without a rival; but it is not much as a wool grower. It yields a light fleece of short, curly wool. Other familiar mutton sheep are the Suffolks, Hampshires, Oxfords and Dorsets, all of which share the same general characteristics. In addition to these there are several other varieties of British sheep which produce wool of special value for certain purposes. Among them are the Shetland and Cheviot sheep, both Scottish breeds. Cheviot wool is especially in demand for tweeds and Shetland wool for hosiery and knit underwear. Some Welsh and Irish wools also are highly valued by British manufacturers. The best of the Irish sheep is the Roscommon, which is a cross between the Leicester and a native breed.

It may easily be imagined that between the different classes of sheep mentioned above, and their multitudinous crosses, the different varieties of wool are beyond number. While, strictly speaking, the wool from any crossbred sheep is properly described as crossbred wool, the term crossbred as used in the wool trade refers only to wool from crosses between the merino and other breeds. Such wool is usually described according to the proportion of merino blood in the breed. A pure merino crossed with a pure long-wool sheep, for example, would produce a ½-blood, and a ½-blood crossed with a long-wool would produce a ¼-blood, and so on. The terms ½-blood, ¼-blood, etc., are frequently used, however, to describe wool of a certain quality, without reference to the proportion of merino blood. In Australia there is a common variety of sheep known as "comebacks," which result from breeding crossbreds back to the merino side.

Besides the various classes of sheep already mentioned there is still another class which produces low-grade wools, known in the trade as carpet wools. These wools come from native sheep which have not been improved by breeding. Nowadays most of the carpet wools come from Asia Minor, Mongolia, India, China and Russia, as well as from certain mountainous districts, such as the Pyrenees and the Scottish Highlands. Although, in this country at least, such wools are used chiefly for carpets, they are also used largely for low-grade woolens, coarse blankets, felt, carriage robes and various other purposes.

Chapter IV

The World's Wool Production

EXACT estimates have never been made of the total wool production of the world. Such estimates, in fact, have always been impracticable, as sheep raising is carried on in many regions where there is no official census in existence. However, the bulk of the wool used in the world's commerce is raised in countries from which official returns are available and in which conditions have not been disturbed greatly by the war, so that it is possible at least to arrive at an approximate estimate of the world's supplies.

All authoritative estimates give the total production of wool as about 2,800,000,000 pounds annually. Of this about 40 per cent is produced in the British Empire, about 15 per cent in South America and Russia, respectively, and about 10 per cent in the United States. Most of the remaining 20 per cent is produced in Continental Europe and Asia Minor. There is reason to believe that the wool production of China and Mongolia is large; but no estimates of its amount are available, and only a comparatively small volume of low grade or carpet wools from these countries find their way into the world's commerce.

Easily the most important of the wool producing countries is Australia, which produces annually about 650,000,000 pounds, or more than one-fifth of the total world supply. Over 80 per cent of the Australian wool is merino, although there is being produced an increasing quantity of crossbred wools, obtained chiefly by crossing the merino with the Leicester and Lincoln. This tendency to substitute crossbreds for merinos seems bound to develop rapidly in Australia, owing to the profits of the mutton trade and the encroachment of small squatters on the big ranches. The principal merino wools of Australia are classed as Port Phillip or Victoria, Sydney or New South Wales, Queensland, West Australian or Swan River, and Adelaide or South Australian.

Port Phillip is recognized as one of the best wools in the world,

ranking almost as high as the best Saxony merino. It is used for the finest woolens and worsteds, and it is especially in demand by makers of very fine woolen yarns, because of its exceptional felting qualities. Sydney wools also have excellent felting qualities and are very soft and elastic, but they are inferior in color and strength to the Port Phillip sorts. Queensland wools are soft and of good color, but are inferior in strength and elasticity. West Australian wools are comparatively coarse, while Adelaide wools, although of good quality, are very dirty, with sand and excessive yolk or grease.

In addition to these varieties, there is a very good merino wool produced in Tasmania, which is commonly known as Van wool. It is a very clean white in color, and is therefore especially suitable for goods which are to be dyed in light shades. Australian crossbreds are classed as comebacks or extra fine, fine, medium and coarse. The first-named, as mentioned in the preceding chapter, is a variety obtained by breeding a crossbred back to the merino side. It is practically equivalent to merino wool in quality, although averaging somewhat longer in staple.

New Zealand produces annually about 117,000,000 pounds of wool. Fully 80 per cent of this is crossbred wool, obtained by crossing merinos with Romney Marsh, Leicester or mutton breeds. The New Zealand pure merino wool is somewhat coarser than the finest Australian, but otherwise equal to it in quality. South Africa (including Cape Colony, the Orange Free State, the Transvaal and Natal) produces about 200,000,000 pounds of wool annually. Most of the South African product is a cross between the merino and native breeds, and is inferior to Australian wool in strength, waviness, elasticity and felting quality. But the best variety of South African merino wool, known as Cape Snow White, is of exceptionally good color and is equal in quality to the finest Australian.

Among the other wool producing areas of the British Empire are India, Canada and the Falkland Islands. The production of British India is estimated at about 60,000,000 pounds annually. This includes some of the best known varieties of carpet wools, such as Joria, Vicanere and Kandahar. Canada produces about 11,000,000

This Is How Wool Looks When Received at the Mill. It Comes in Bags in Which the Fleeces Are Tied Together, Waiting to Be Sorted Into Their Various Qualities

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pounds annually, mostly from sheep of the mutton varieties. The production of the Falkland Islands is comparatively small, about 4,000,000 pounds annually; but most of it is Cheviot wool of good quality and especially suitable for the making of tweeds and similar fabrics. In the United Kingdom the annual production of wool amounts to between 120,000,000 and 125,000,000 pounds. Most of this comes from sheep of the Down and Cheviot breeds or from crosses between these and the Lincoln and Leicester breeds.

In South America the total annual production of wool amounts to about 400,000,000 pounds, most of which is produced in Argentine and Uruguay. In Uruguay about 80 per cent of the wool is from fine merinos, chiefly of the French Rambouillet breed. The remainder, for the most part, is from crossbreds of merino ewes with Lincoln or Romney Marsh rams. About 75 per cent of the Argentine wools are crossbreds of merino with Lincoln or mutton breeds, the rest being pure merino. Generally speaking, the South American merino wool is much more burry, greasy and dirty than the Australian varieties. The wools from Uruguay are usually referred to as Montevideo wools, while those from the Argentine are usually referred to as Buenos Ayres wools. The former, on the whole, are the more desirable. There is in addition a considerable production of wool in Tierra del Fuego, known as Punta Arenas wool, from the port of shipment. This is somewhat coarser, more tender and more kempy than the Montevideo and Buenos Ayres varieties.

In the United States the annual production of wool averages between 250,000,000 and 300,000,000 pounds. Little more than half of this is merino. The chief wool growing states, in the order of their importance, are Wyoming, Montana, New Mexico, Idaho, Ohio, Oregon, Utah, California, Michigan, Colorado, Texas, Pennsylvania, Wisconsin, Missouri, Nevada, Indiana, Iowa, Arizona, New York, Illinois, South Dakota, Washington, Kentucky, West Virginia, Minnesota, North Dakota, Virginia, Nebraska, Kansas, Maine, Tennessee and Vermont. Of these, Wyoming and Montana produce between them about 70,000,000 pounds annually.

It is generally taken for granted that the production of wool in the United States is declining, but this assumption is not borne out by the records. Figures of production covering the last thirty years show, on the whole, a fluctuating tendency. For example, from a high point of over 348,000,000 pounds in 1893, production declined to about 259,000,000 pounds in 1897. Then it gradually rose to more than 316,000,000 pounds in 1902, slumping suddenly to about 287,500,000 pounds in 1903, rising again steadily to 328,000,000 pounds in 1909, and again declining to about 229,000,000 pounds in 1919. Production in 1920, which amounted to about 259,000,000 pounds, was practically the same as the production for 1897.

Among the other wool producing countries of the world, the most important is Russia, which yields nearly 400,000,000 pounds annually—or did before the revolution. A large proportion of this is carpet wool. The Russian carpet wool imported into this country is generally known as Donskoi wool, although strictly speaking Donskoi is the name of a special variety of Russian wool. It is used for the best domestic velvet and Axminster carpets. Russia produces also a considerable amount of good clothing (merino) wools, the best of which are known as Odessa wools. These are strong, fairly fine wools, of exceptionally good color. Georgia, which for convenience may be included in Russia, produces some of the finest carpet wools imported into this country. The production of Turkey and Asia Minor is practically all carpet wool. Outside of Turkey and Russia, Continental Europe produces altogether about 265,000,000 pounds of wool annually.

More than half the total world production of wool is consumed by Great Britain and the United States. Consumption of wool in the United States in recent years has averaged around 700,000,000 pounds, while consumption in the United Kingdom averages between 800,000,000 and 850,000,000 pounds. It is worth noting that consumption of wool in the United States is more than twice the domestic production, while consumption of wool in the United Kingdom is considerably less than the total production of the British Empire. This exactly reverses the situation existing in cotton. The other

chief consuming countries are France, Germany, the former empire of Austria-Hungary and Italy. The precise figures for these countries are not available, but they may be estimated as approximately 480,000,000 pounds for France, 400,000,000 pounds for Germany, 60,000,000 pounds for Italy, and 140,000,000 pounds for the countries comprising the former Austro-Hungarian Empire.

Chapter V

Classification and Marketing of Wool

MOST of the world's sheep are raised either on large ranches or on small farms in connection with dairy or other produce. The former is the prevailing method in Australia, South America and the western United States, while the latter prevails in such regions as the Middle West, England and Continental Europe. In addition, large numbers of sheep are raised by primitive pastoral methods in remote mountain districts, such as the Highlands of Scotland, the Pyrenees, and the plateaus of Central Asia. These, as a rule, are unimproved native varieties, and their wool comes under the general heading of carpet wool.

The gradual reduction of great sheep runs by the increase of population in sparsely settled territories creates a serious problem as to the world's future wool supplies. A farmer raising from 20 to 100 sheep cannot do it as cheaply as a rancher raising 20,000 to 30,000 sheep. In fact, the small profits of sheep raising, as compared with other farm products, is the main reason for its decline in farming districts. For this reason alone the disappearance of the big ranches will in all probability mean much higher prices for wool. Besides, the necessity of obtaining a given quantity of wool from 200 to 300 farmers instead of from one rancher will increase the difficulty of marketing and classifying wool.

On the other hand, there may be a great saving through the better care which farmers, properly instructed in scientific methods, can give to small flocks. At present sheep raising is, in a financial sense, an extremely hazardous occupation, for the loss of sheep through various causes, especially on the large ranches, is very high. In Australia and the Southwest of the United States, for example, there are frequent and heavy losses through drought. In states such as Montana and Wyoming thousands of sheep may be killed in a blizzard. At lambing time, particularly if the weather is bad, there is a great loss of lambs. The loss on ranches from this cause alone averages over

10 per cent. Then there is loss through wild animals, poisonous plants, disease and other causes.

Generally speaking, the raising of wool for market involves little effort except that involved in the care of the sheep. A periodical disinfectant dip, for the purpose of killing ticks and other parasites, is about the only treatment necessary before shearing. In some localities, particularly in England, it is customary to wash the sheep before shearing. This washing removes some of the dirt and grease from the wool and makes it lighter for shipment, but as a subsequent scouring is always necessary this preliminary washing of sheep is not generally considered worth while. Wool from sheep which have been washed before shearing is known in the markets as washed wool.

Originally wool was obtained from the sheep's back by the simple process of pulling it out, as feathers are obtained from a dead bird, and this barbarous custom still survives in many isolated parts of the world. But almost universally nowadays the wool is sheared off either with a hand shears or by machine. The hand shears naturally is the method employed on small farms, but on the ranches machine shearing is the rule. Shearing time varies in different parts of the world—April and May in the United States, for instance, September and October in Australia, November in New Zealand, January in Tasmania, June and July in Great Britain, and so on.

When the shearing is properly done the whole fleece from the sheep holds together in one sheet. This is skirted to remove the stained britch wool and the dirty wool round the edges of the fleece. It is then rolled up, tied, and packed in bales for shipment. In most countries the sheep farmers, especially the small farmers, make no attempt to classify their wool, the classification being done by the wool dealers. But in Australia it is customary to classify the wool on the ranch before shipment, because the ranchers as a rule can afford to employ expert sorters and because sheep breeding in Australia is sufficiently standardized to permit some approach to an exact classification.

The accurate classification of wool presents almost insurmountable difficulties. The qualities of wool vary not only with the different breeds of sheep but with the health of the sheep, with variations in

soil and climate, and with innumerable other conditions. Pure bred merino sheep from South Australia, Tasmania, Uruguay and Montana, for example, will present so many differences as to be practically different varieties. The wool of sheep raised in the rich pastures of Ohio, to give another instance, will differ altogether from wool of exactly the same variety of sheep raised on the arid lands of New Mexico. And when it is remembered that farmers in the same locality will cross and intercross different breeds of sheep without reference to any accepted standard, it can readily be understood that anything like an accurate classification of wool is next to impossible. When the New York Wool Exchange was established some years ago it defined two hundred grades of American wool, but found after a time that this number of grades was not nearly sufficient.

A rough classification, generally adopted for convenience, divides all wools into combing, clothing and carpet wools. At one time this classification was loosely accurate, as only long staple wools could be combed. But nowadays it is possible to comb both short staple and long staple wool. However, the term combing wool is generally understood to mean a long staple wool of good quality. All shorter staple wools suitable for clothing are grouped under the heading of clothing wools. These terms are particularized by adding the breed of the sheep and the locality in which the sheep was raised.

In Australia, where the classification of wool is more nearly on a scientific basis than in any other country, merino wools are classified as super combing or supers, first combing, second combing, and clothing. Crossbreds are classified as comebacks or super crossbreds, first crossbred combing, second crossbred combing, and third crossbred combing. Pure bred long wool sheep are classified as extra luster hoggs and luster wethers. In other countries there are no such definite classifications, and wools from these countries are quoted on the market in some such loose manner as Argentine high quarter blood or Argentine Lincoln.

In the United States there is a great variety of classifications, but none that is accurate or comprehensive. There are a number of terms, however, which are in general use in the trade and have a fairly definite

HERE IS SHOWN A SERIES OF CARDING MACHINES. WOOL IS BEING FED INTO THE NEAREST ONE, TO BE STRAIGHTENED OUT BY THOUSANDS OF SMALL TEETH ON REVOLVING DRUMS.

meaning. For example, Eastern and Middle Western wools are commonly classified as fine delaine, XX, half blood, three-eighths blood and quarter blood. Both fine delaine and XX are pure merino wools. The other terms, although meaning strictly the proportion of merino blood, are used to indicate the quality of the wool without reference to the amount of merino blood in the sheep. Wools from the Northwest are known as Territory wools and are classified as fine staple, fine medium staple and fine medium clothing. Texas wools are classified as fine fall, medium fall, twelve months and eight months. California wools are classified as spring, northern and fall; New Mexico wools as Nos. 1, 2, 3, 4, and so forth.

The British method of classification ignores all these subtleties and describes wool according to the number of the yarn it will spin, such as 40's, 60's, 70's and so on. The meaning of these yarn numbers will be described in a later chapter. All wools are quoted on the English market in this way, without any other qualification except, as a rule, the name of the region from which the wool comes, as for example, Geelong 60's or Sydney 80's. The 60's wool is taken as a standard for purposes of comparison, like Middling Upland cotton or Sinshiu No. 1 silk. As the working and spinning qualities of wool are the really important things to know about it, this system of classification is about as useful and accurate as any that it is possible to devise.

All wools sheared from the sheep are known as fleece wools. Most of them are sheared from full-grown sheep at regular seasons, but a certain proportion of them are obtained at special times and are known by special names. Lamb's wool, for instance, is wool sheared from sheep less than a year old; hogg or hogget wool is from a year-old sheep which has not previously been sheared; wether wool is a term applied frequently in the United States to wool from a castrated male sheep, but is used elsewhere to mean the wool of any sheep from which the hogget fleece has been sheared previously.

In addition to fleece wools there is a large class of wools obtained from the skins of slaughtered sheep and known as pulled wools. Usually these wools are loosened from the skin by means of sodium sulphate or lime, although in Mazamet, in the South of France, which is

the center of the world's trade in sheepskins, they are loosened by a rotting process. The increasing custom of breeding sheep for mutton as well as for wool is leading naturally to an increase in the production of pulled wool. On the whole this class of wool is decidedly inferior to fleece wool grade for grade.

In judging the market value of wool the most important considerations are condition, quality, strength and length of staple, and color. The condition of wool refers to the amount of grease and dirt it contains. All wool contains a certain amount of fatty matter from the sheep's skin, as well as dust, burrs, seeds, excrement and other dirt. The amount of fatty matter—known as grease or yolk—contained in a fleece depends upon the breed of the sheep and the conditions under which it has been raised. Wool, therefore, is described as light conditioned or heavy conditioned, and the percentage of weight it loses when it is scoured is known as the shrinkage. The shrinkage of different classes of wool may vary anywhere from 10 to 75 per cent. The average shrinkage of pure English long wools is about 30 per cent, of medium crossbreds about 40 per cent, and of pure merinos about 50 to 60 per cent. When the price of wool is quoted on a scoured basis it means a price based on the estimated shrinkage of the wool in scouring. Thus a price of $1 a pound scoured basis for merino wool that shrinks 50 per cent would mean a price of 50 cents a pound for the same wool in the grease. Quality, as the term is used in the raw wool trade, refers to the fineness of the fiber.

Wool is marketed in a wide variety of ways. In Australia and New Zealand the prevailing method of marketing wools is by public auction, and this too is the method followed in England for all except domestic wools. The auctioning system is followed to a limited extent in South Africa, South America and the ranching country of the United States, but the method usually practised in these countries is private sale by growers to local dealers, manufacturers, or large merchants or commission houses in the central markets. London is perhaps the world's greatest wool market. Auctions of wool are held there in January, March, May, July, September and November. For a long time the bulk of Australasian wools were sold at these London auctions,

but in recent years the auctions at Melbourne, Sydney, Brisbane, Geelong and Adelaide in Australia and at Wellington, Napier and Christchurch in New Zealand have been accounting for most of the Australasian clip, although a considerable amount of the wool sold at these auctions is eventually resold in London.

Liverpool is a great market for South American wools, as well as for carpet wools, mohair and alpaca. The auctions are held there in the same months as the London auctions, and are timed to start when the London auctions close. Antwerp and Bremen are the chief Continental wool markets, the former dealing principally in South American wools and the latter chiefly in Australian wools. Havre also is of some importance as a wool market. In South Africa and South America foreign buyers or their representatives purchase the wool direct from growers or local dealers, or else do their buying in the open markets of Port Elizabeth, East London, Durban, Buenos Ayres, Montevideo or other centers. Some of the big growers consign their wool unsold to the auctions at Antwerp, Liverpool or London; but this is not a common practice.

Whether wool is marketed by the auction system, as in Australia, or by private treaty, as in the United States, the bulk of it finds its way into the hands of big wool merchants in important trading centers. These merchants have buying representatives in the principal wool markets of the world and often in all the woolgrowing regions as well. Not infrequently they finance growers wholly or in part. Sometimes they buy the wool outright and sometimes they act merely as commission agents, buying and selling the wool on commission. There are some cases in which mills buy direct from growers and some cases in which co-operative organizations of growers act as selling agents for their members, but the amount of wool handled in this way is comparatively small. Wool sales all over the world are usually spot transactions for cash.

In England there is a class of merchants, called topmakers, who are an intermediate step between the wool merchant and the manufacturer. Tops is a name applied to wool from which the short and broken fibers have been combed out. The topmakers as a rule have the combing

done for them by firms which make a specialty of such work, and they deal only in combed wool. The short and broken fibers rejected in the combing are known as noils. The uses of these will be dealt with in a later chapter. English dealers and manufacturers for the most part buy combing wools on the basis of the yield of tops and noils. American and Continental European manufacturers and dealers buy wool on the basis of the clean scoured yield. Thus, for example, a price of 40 cents a pound for grease wool on the spot would be estimated to work out at, say, $1.15 a pound clean landed basis.

Boston is the principal wool market of the United States. It owes this position to its proximity to the woolen manufacturing industry, which is centered in New England. Philadelphia and Chicago come next in importance. New York also is of some importance because of its position as a shipping point and its proximity to many large mills.

Chapter VI

Preparatory Manufacturing Processes

WOOL reaches the mill in fleeces packed in bales of 100 to 500 pounds each. As the wool from different parts of a sheep varies in quality, each fleece contains a number of different qualities, and the first process necessary after the wool reaches the mill is to sort it out. This is a job requiring not only expert knowledge of wool, but an intimate acquaintance with the requirements of the mill. Any two equally expert sorters are apt to sort the same fleece differently. Again, a mill may sort a fleece into four classes, while another mill, making a different type of goods, may sort the same fleece into ten classes. Furthermore, fleeces from different markets must be sorted differently. An Australian merino fleece, for example, which has been skirted and britched before shipment and in which the wool is fairly uniform, requires very little sorting, while a dirty, unskirted domestic fleece may need a good deal.

Generally speaking, the best wool is that which comes from the shoulders and sides of the sheep. Next in the order of value is that from the lower part of the back, the loin and back and the upper part of the legs. Wool from the neck, britch, belly, chest, head, throat and lower part of legs is all inferior. When the fleece is deeply skirted before being shipped to market, as is customary in Australia, practically all this inferior wool is removed. A light skirting may leave a certain amount of it in the fleece, while an unskirted fleece contains all of it. Apart from this rough-and-ready classification, the wool sorter has no guide except his own judgment and his familiarity with the manufacturer's requirements.

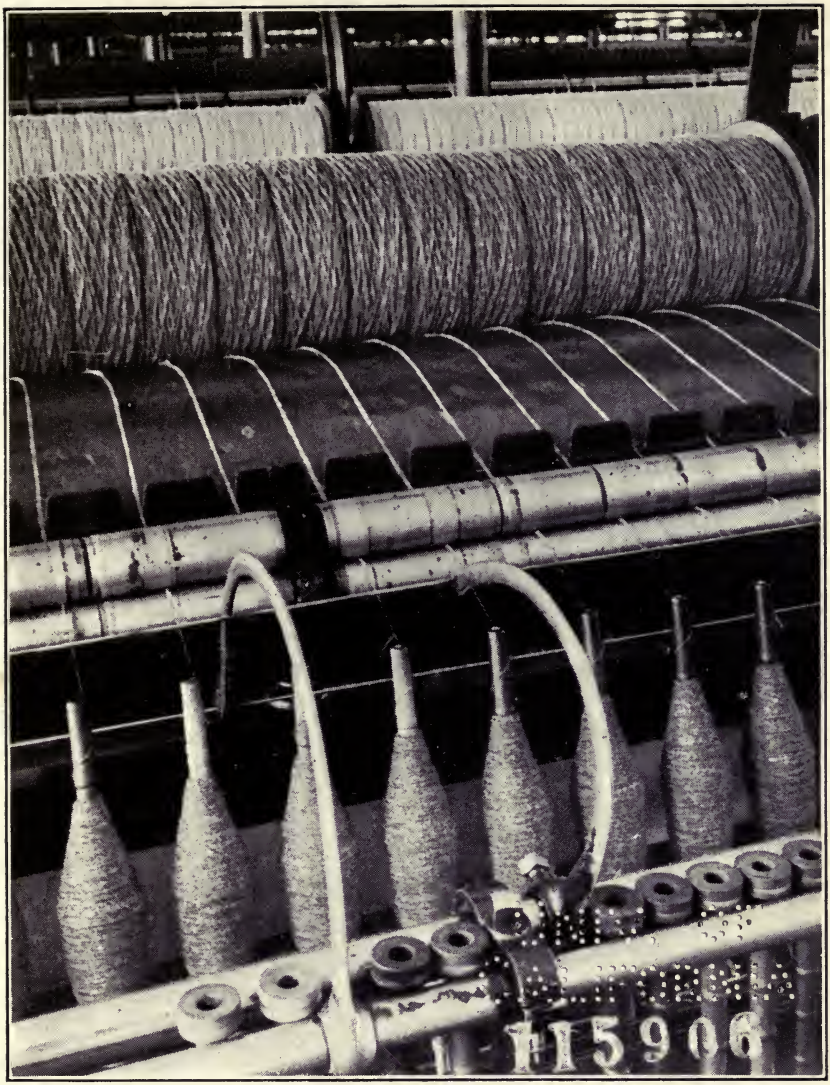
In the operation of sorting the fleece usually is spread out on a table, the center of which is covered with wire netting. Working inward from the edges of the fleece, the sorter tears out different parts with his hands and places them in separate piles, according to the different qualities. The fleece is banged and shaken on the table

so that a good deal of the dust and loose dirt in it falls through the wire netting. In addition the sorter removes from the fleece with his hands all lumps of dirt, matted fibers, large burrs and other roughage which can be removed in this way without too much expenditure of time and labor. Low grade wools, especially carpet wools from Asia and Southeastern Europe, are likely not only to be excessively dirty but to contain the germs of anthrax and other infectious diseases, so that the sorter has to take great precautions in handling them.

Besides dust, burrs, fodder and other foreign matter, all wools contain a considerable proportion of suint or yolk, usually known as grease. The latter is partly perspiration and partly a fatty exudation from the sheep's body, which seems to serve the purpose of protecting the wool on the sheep's back from injury by the weather. All dirt and grease must be removed before the wool can be worked properly. This is done as a rule by scouring the wool in warm water, soap and a mild alkali, such as ammonium carbonate or some similar substance. In the process of scouring the wool passes through three or four vats filled with the scouring liquid. Each vat is equipped with automatic rakes, which stir the wool in the liquid, and with a set of rollers which squeeze the liquid from the wool before it passes to the next vat.

Great care and skill are necessary to avoid injury to the wool in scouring, as the fibers may easily be injured by too much stirring, by water that is a little too hot or an alkali that is a little too strong. Some big manufacturers employ what is known as the solvent system of scouring. By this system the wool is treated with some chemical agent, such as ether, naphtha, benzine, alcohol or carbon bisulphide. This system has the advantage of being economical, for the chemical solvent, after being distilled, can be used over again and the by-products of the scouring can be easily recovered. It also avoids the danger of injury to the wool fibers from the stirring about which is necessary in the ordinary scouring bath. But it is advantageous only to big mills which handle great quantities of wool.

After the scouring the wool is carried on a belt to the drying



THIS IS PART OF THE SPINNING PROCESS. THE WOOL HAS BEEN STRAIGHTENED AND TWISTED INTO YARN, WHICH THE PICTURE SHOWS BEING WOUND ON TO BOBBINS

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chamber, where most of the moisture is removed by bringing it into contact with warm air. Sometimes the drying is done by a centrifugal machine known as a hydro-extractor. Wool is never made absolutely dry, for absolutely dry wool tends to kink and curl and break in the working. A certain amount of moisture is always allowed to remain, the standard allowance being 16 per cent. But merino wools, which are comparatively short and curly, are allowed to retain more than 16 per cent of moisture, and, in fact, are not usually put through any drying process at all.

When the wool contains large burrs and other matter which does not come out in the scouring it is put through a burring machine, which picks out the larger impurities. When the burrs are small and numerous and there is a large amount of other vegetable matter present, the burring process is not sufficient and the wool must be put through a supplementary process known as carbonizing. This consists of steeping the wool in a solution of sulphuric or hydrochloric acid and subsequently drying it in an oven heated to about 160 or 170 degrees Fahrenheit. The acid attacks all the vegetable matter and reduces it to a state resembling charcoal. Sometimes the carbonizing is done with hydrochloric acid gas instead of with an acid solution. This method is known as dry carbonizing. The carbonized matter easily crumbles into dust, which may be shaken or blown out of the wool.

After being burred and carbonized the wool is blown through pipes or carried on trucks into the carding room. The subsequent processes depend largely upon whether it is to be made into woolen or worsted goods. Fundamentally the difference between woolens and worsteds is that in woolen yarns the fibers intercross and are mixed up with one another in a more or less haphazard way, while in worsted yarns the fibers all lie parallel to one another. Formerly it was practicable to comb only long staple wools, and worsteds consequently were made only from such wools. But some modern combing machines can comb wools of any length, and as a result worsteds can be and are made from both long and short staple wools, although long staple wools are most commonly used.

In the woolen trade, and to some extent in the worsted trade, it is a common practice to dye the wool after scouring. Yellow-tinted and discolored wools, especially if they are intended for goods which are to be finished white or dyed in light colors, are sometimes submitted to a blueing or bleaching process before dyeing. The blueing process for yellow-tinted wools consists in treating them with a dilute solution of an acid blue or violet coloring matter, which is complementary to the yellow and unites with it to form a neutral tint. Wool is bleached usually with sulphur fumes. Sulphurous acid and hydrogen peroxide are used also to some extent.

Whether the wool is dyed in the stock or not, the next process is the mixing or blending. This is practised chiefly in the woolen trade. Its object is either to obtain a certain quality of yarn from certain blends of raw stock or else to produce certain colors. Every manufacturer finds by experiment that various blends of wool will produce characteristic results, and he develops his own formulas for achieving the effects in which he specializes. For certain kinds of goods the raw wool is mixed with cotton or shoddy. Sometimes a small percentage—as little as 5 per cent—of strong long-staple cotton, such as Peruvian cotton, is blended with the wool in order to lend strength to warp yarns. By blending different colors in the raw stock, various plain and mixed color effects are obtained in the finished goods.

Either before or after mixing—but usually before—the wool is sprayed lightly with oil, so that it will work more smoothly and evenly through the machines. Olive oil is used as a rule for this purpose. The cotton is then fed to the carding machine. This consists essentially of two revolving cylinders, both of which are covered with fine wire teeth. The wool is fed to these cards automatically from hoppers. The cylindrical cards revolve in opposite directions, so that some of the wool fibers are drawn forward while others are drawn back. As a result the mass of wool fed to the carding machine is brushed out into a thin flat sheet, resembling a sheet of cotton batting. This sheet is condensed into a soft, narrow band or

rope, known as a roving. It is then wound on large spools or bobbins and taken to the spinning room to be spun into yarn.

For worsted yarns the wool has to go through even more preparatory processes before it is ready to be spun. As a rule it goes first through the various processes already described, including carding but excluding blending and dyeing. Long wools of seven inches or more in staple are prepared for combing by being placed in a preparing box which opens up the wool, combs the fibers apart and lays them parallel or nearly so. Shorter wools are carded. In either case the wool is fed next to the gilling machine, which straightens out the fibers still more. It comes from this machine in soft strands, which are taken to the balling machine and made up into large balls, each containing four strands. Eighteen of these balls make a set for the combing machine. Sometimes before the gilling process the wool is submitted to a second scouring operation, known as backwashing, in order to remove any dirt that may remain after the carding. This is done frequently by topmakers to improve the color of the tops.

The operation of combing consists simply of straightening out the fibers and removing the short, broken and knotted ones. Although it sounds simple in theory, it is a very complicated operation in practice, and requires highly specialized machinery. The most widely used combing machines are the Noble comb and the French or Heilmann comb. The latter is especially adapted for combing short wools, and, in fact, it can be adjusted to any length of staple. As already mentioned, it is usual to use long staple wool for worsted yarns, but for certain purposes, such as knit goods or soft dress goods, where a soft, thick yarn is desired, wool of very short staple can be used to advantage. The chief object of combing, therefore, is to straighten out the fibers and make them clean and uniform. From the combing machine the wool comes in the form of a fine sliver known as a top. The broken, short, knotted and otherwise imperfect fibers removed by the comb are known as noils. These are sold to woolen spinners and mixed with raw stock to be spun into woolen yarns.

A number of slivers from the combing machine are combined into one and run through gill boxes, where they are combed again and reduced to strands of uniform size. These strands are wound into large balls, which are known as finished tops. They are then ready for the spinning room. Sometimes the wool is dyed before being sent to the spinning room—or dyed in the top, as it is called in the trade. In this case it comes back to be gilled and recombed before it is ready to be spun.

Chapter VII

Spinning Woolen and Worsted Yarns

SPINNING is the process by which the wool is drawn out and twisted into thread. In the modern mill, however, the drawing and twisting are done for the most part by separate machinery, so that the term spinning is applied merely to the twisting part of the process. The amount of drawing given to the wool before it is spun depends upon the size and nature of the yarns required. Generally speaking, a lot of drawing is done for worsted yarns and very little for woolen yarns. The strand or sliver of wool from the finished worsted top may be subjected to as many as nine drawing processes, each of which draws it out a little finer. In the final drawing process, it is given usually a very slight twist; although when a soft worsted yarn is to be produced this twist is omitted. After it has come through the drawing machine the worsted strand is known as a roving. For woolen yarns the sheets of wool which come from the carding machine are reduced, by means of a machine called a condenser, into soft strands, known also as roving.

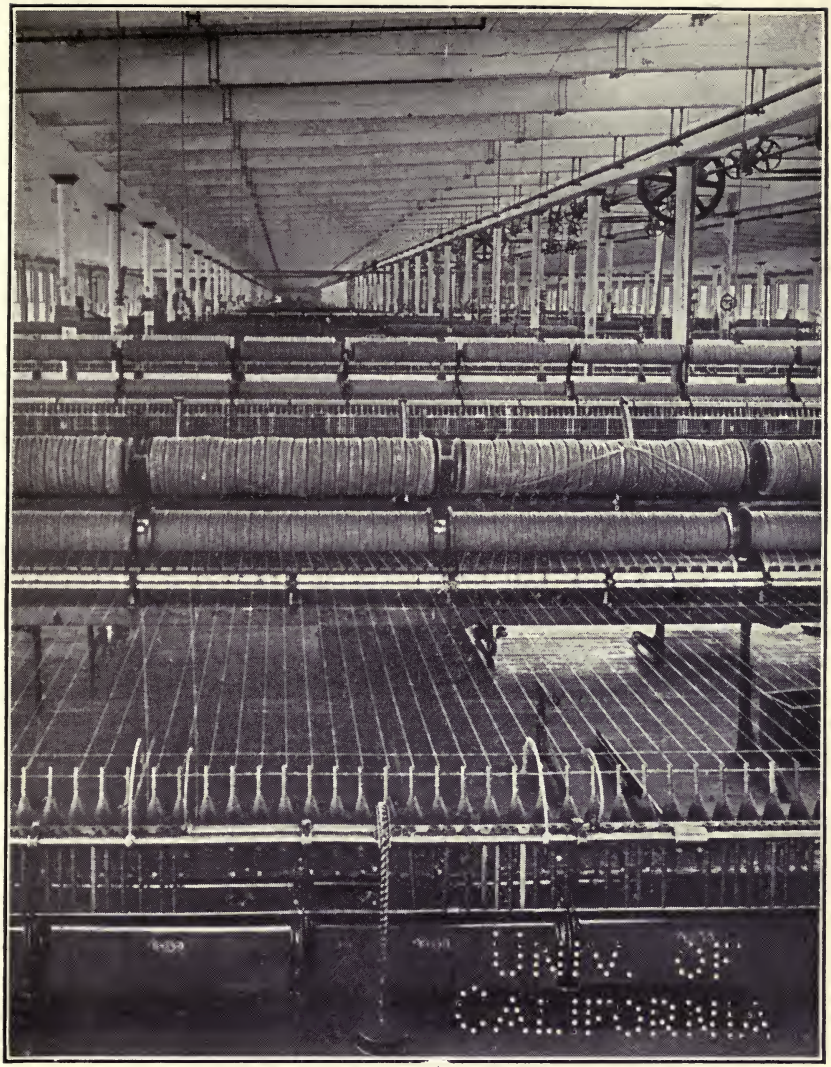
Woolen yarns, and some worsted yarns, are subjected to a further drawing in the spinning process proper. The original method of spinning, presumably, was to draw out the wool into strands with the fingers and twist it into thread. If one will do this with a piece of cotton wool, for example, one will have a practical illustration of the fundamental principle of spinning. This method of course was extremely tedious, and eventually somebody hit upon the idea of using a stick instead of the fingers for twisting the thread. The stick was operated by twirling it with the palm of the hand against the thigh. In order that it might revolve more easily and rapidly a piece of stone, metal or other heavy substance was attached to the top of it. Such was the primitive spindle, used the world over until comparatively modern times.

The first important improvement was the invention of the spinning wheel. This originated in India probably—at what period is not known—and it made its first appearance in Europe toward the

end of the fifteenth century. It consisted of a spindle to twist the thread, a wheel to turn the spindle and wind the finished yarn, and a distaff to hold the raw material. At first the distaff was held in the hand or stuck in the belt of the spinner, but later it was attached to the machine. Eventually the machine was operated by a treadle instead of by hand. No further improvement in the art of spinning was made until 1764, when James Hargreaves of Blackburn, England, invented a machine known as the spinning jenny. In principle this machine was the same as the old spinning wheel, except that it twisted several threads at one time.

So far the operations of drawing and twisting had always been conducted simultaneously, and this principle was adhered to in the Hargreaves spinning jenny. But in 1769 a spinning machine on a totally different principle was invented by a man named Arkwright in Preston, England. In the Arkwright water frame, as it was called, the material was first drawn out to the required fineness by a series of rollers, each running faster than the one behind it, and was then twisted to the required degree. It is important to remember that worsted yarns are spun on the new principle embodied in the Arkwright machine, while woolen yarns are spun on the old principle embodied in the Hargreaves machine. In other words, worsted yarns are first drawn out and then spun, while woolen yarns are drawn and spun at the same time.

In 1779 Samuel Crompton of Bolton, England, gave to the world a new machine called the Crompton mule, which combined the best features of both the Hargreaves and the Arkwright machines—hence its name. The spindles of the mule are mounted on a movable carriage which works back and forth, drawing the strands of wool as they are paid out by the rollers, twisting them into yarn and winding the yarn on bobbins. All woolen yarns, and some soft worsted yarns, are spun on the mule type of machine. For spinning woolen yarns the machine is equipped with only one set of rollers, which merely feed the roving to the spindles. The drawing is done by the spindles as they move away from the rollers, twisting the roving into yarn.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This Picture Shows Part of a Mule Spinning Room. The Part of the Machine in the Foreground Moves Back and Forth, Drawing Out and Twisting the Yarn.

In spinning worsted yarns the roving is drawn out through a series of rollers, as in the Arkwright machine, and then twisted into yarn. Nowadays, however, the mule is used for worsted spinning only when soft yarns are desired, such as yarns for fine knit goods and certain fine dress goods. Most worsted yarns are spun on a type of machine known as a cap-frame or ring-frame spinner. It was invented by Richard Roberts in 1835 and has since been subjected to various improvements which have made it the most rapid and economical type of spinning machine. The essential difference between this type of spinner and the mule is that the spindles of the former are stationary. The cap-frame is faster than the ring-frame, but produces a somewhat rougher yarn. Both spin a much harder yarn than the mule.

Woolen and worsted yarns, like cotton yarns, are numbered according to size, but unfortunately there are various systems of numbering used in different countries and there is no standard system which is generally recognized. In the United States woolen yarns are numbered, as a rule, either according to the "American run" system or the "Philadelphia cut" system. The former is based on the number of runs of 1600 yards that weigh a pound. Thus, if a run of 1600 yards weighs one pound the yarn is known as a No. 1, while if ten runs of 1600 yards, or 16,000 yards, weigh one pound, the yarn is known as a No. 10. The Philadelphia system is based on the number of cuts of 300 yards that weigh one pound. Thus a yarn weighing ten cuts, or 3000 yards, to the pound would be a No. 10 yarn. According to the English system the number of a woolen yarn is the number of skeins or hanks of 1520 yards each that weigh six pounds. There are also French, Prussian, Viennese and other systems of numbering woolen yarns.

For worsted yarns there is a nearer approach to a standard system of numbering. The accepted system in England and the United States is based on the number of hanks of 560 yards that weigh one pound. Thus, if one hank of 560 yards weighs a pound the yarn is known as a No. 1, while if it takes ten hanks, or 5600 yards, to weigh a pound the yarn is known as a No. 10—and so on.

Obviously the higher the number the finer the yarn. Worsted yarns have been spun as high as 140's, but it is practically impossible nowadays to find wool that will spin higher than 100's.

Worsted yarns below 40's are described as coarse; yarns from 40's to 60's as medium, and yarns from 60's to 100's as fine. But the number of the yarn does not strictly define its quality, as some very fine, soft, mule-spun worsted yarns are of comparatively low count. In England, yarns spun from Australian merino wool are commonly known as Botany yarns, from the fact that the first English colony in Australia was known as Botany Bay. Frequently two or more worsted yarns are twisted into one yarn, which is called a ply yarn. Ply yarns are designated according to the number of the single yarn, prefixed by a sub-number indicating the ply. For example, two 60's yarns twisted into one would be designated as 2/60's, three 60's yarn twisted into one as 3/60's, and so on.

Woolen and worsted yarns come from the spinning machines wound on cops, tubes or spindles. In this form they are ready for the weaver. To a certain extent spinning and weaving are separate divisions of the wool goods industry, but the division is not exact. Some mills do spinning only; some do weaving only, getting their yarns on contract from spinners or in the open market; some do both spinning and weaving; while many mills which do both spinning and weaving may sell some of their yarn output to other mills or may buy extra supplies or special qualities from outside spinners. There is consequently an open market for yarns, and the fluctuations of this market furnish a fair index of the trend of demand for goods.

Chapter VIII

The Weaving Processes

IT is probable that weaving is the oldest of all textile processes, and that it began with the first attempts of primitive man to weave twigs into mats or baskets. In handling twigs it was easy enough to interlace them with the fingers and without the aid of any other device. But when an attempt was made to weave soft fibers, like wool, it became necessary to stretch a certain number of them between fixed objects, so as to form a groundwork through which other threads could be interwoven. Thus was born the first loom and, crude as it was, it embodied the basic principle upon which all subsequent looms have been built. Essentially weaving is based on the principle of a fixed groundwork of threads, known as the warp, through which by various devices are interwoven other threads, known as the weft or filling.

At first the filling threads were interlaced alternately with the warp threads by hand, much like the method used in darning stockings. This was a painfully slow process. Eventually, however, somebody hit upon the idea of attaching alternate warp threads to a movable piece of wood, by which the set of warp threads attached to it could be raised and lowered, while the remaining warp threads remained stationary. This device, which is known as a heddle, made it possible to pass the filling thread much more rapidly through the warp threads. In addition, the invention of the heddle made it possible to attach the filling thread to some heavy object and throw it through the warp, instead of pulling it through by hand. After each filling thread had been shot through the warp it was pushed into place beside the preceding one by means of a stick.

In the course of time various improvements were made in this original loom. The heddles were developed so that they could be worked by foot treadles. The filling threads were wound on bobbins and placed inside hollow shuttles which were thrown through the warp, unwinding the thread as they moved. The warp threads were wound

on a beam placed at one end of the loom, while another beam at the opposite end of the loom took up the finished cloth as it was woven. This made it possible to weave various lengths of cloth on the one loom. The stick for beating up the filling threads into place was developed into a comb-like affair, called a reed, which did the work more surely and evenly. All the movements of this loom were controlled by hand, except the raising and lowering of the heddles, which were controlled by foot treadles.

An important innovation, which seems to have been developed in the East during the early centuries of the Christian era, and which was brought to Europe from Damascus by the Crusaders, was what is known as the draw loom. This was a device for facilitating the repetition of a pattern. The number of threads in the warp was divided into as many sections as there were repetitions of the pattern. The similarly numbered threads from each section were combined and fastened to a cord. When this cord was drawn it lifted all the corresponding threads of every section.

No further important improvements were made in the loom until the middle of the eighteenth century, when its mechanism was revolutionized by a number of inventions. The first of these was the flying shuttle, a device for driving the shuttle through the warp mechanically instead of by hand, which was invented in 1738 by John Kay, a native of Bolton, Lancashire. His son, Robert, invented in 1760 a device known as a drop box, to hold several shuttles with threads of different colors, which made possible quicker changes in weaving cloths of more than one color. In the latter year a new kind of loom, known as the swivel loom, was introduced into England from Holland. This made possible the weaving of several narrow pieces of cloth at the same time. Soon afterward came the harness-loom containing several sets of heddles, each set attached to a frame called the harness, by which they could be raised and lowered.

In the harness loom the heddles consist of cords or wires suspended in a frame. Each heddle is fitted with an eyelet or loop, and through each of these eyelets or loops a warp thread is passed. For a plain

weave only two harness frames are used, the warp threads being passed alternately through the heddle eyelets of each frame. For twill and satin weaves three, four or five harness frames may be used, so that one speaks of three- or four-harness twills, or five-harness satins, etc. For fancy weaves a large number of harness frames may be used. The harness loom is used for weaving all kinds of plain and fancy fabrics, except those embodying very intricate and elaborate patterns, which are woven usually on a Jacquard loom.

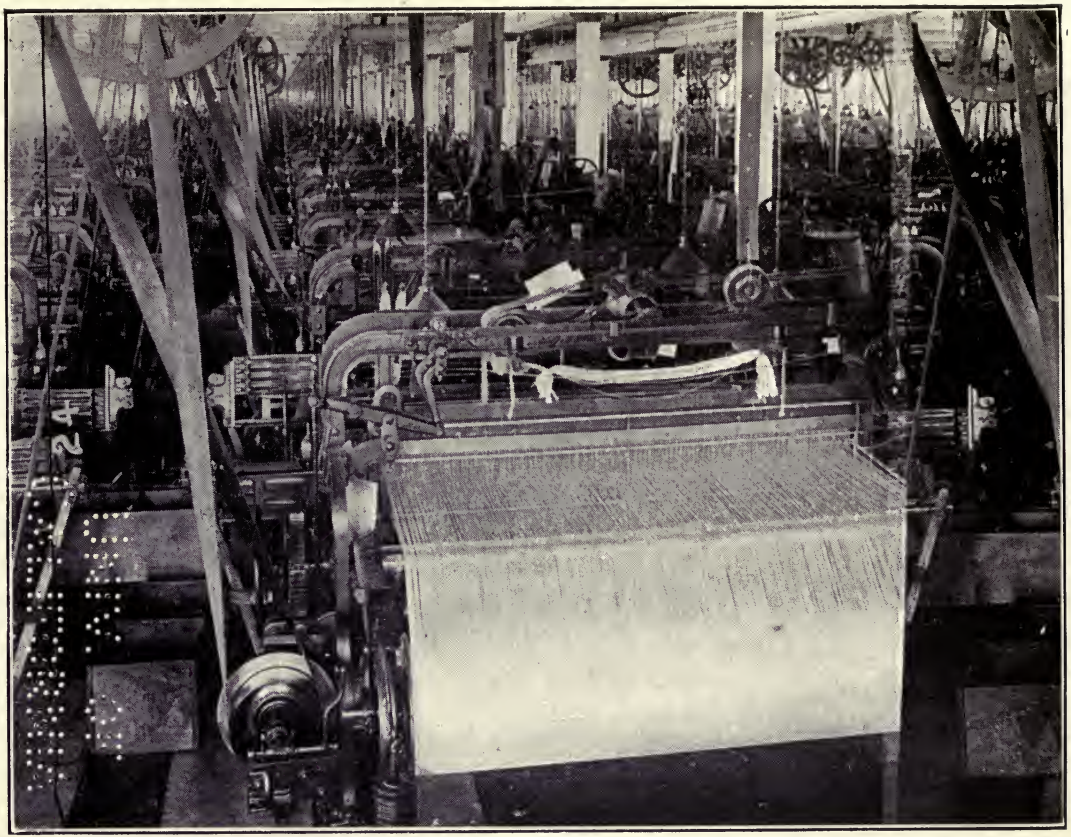
The latter machine was invented by Joseph Marie Jacquard, of Lyons, France, and was first exhibited at the Paris Exposition of 1801. Essentially it is a development of the draw loom, already mentioned. Every thread in the warp is drawn through an independent heddle eyelet. A number of heddles containing one thread from each repeat in the pattern are gathered together into what is known as a lash. Each lash is fastened to a hook by which it is raised or lowered. The raising or lowering of the hooks is controlled by means of holes punched in cards, after the manner of a player piano.

It was well into the nineteenth century before either water-power or steam-power was applied to weaving on any considerable scale. Actually, the power loom was invented by Edmund Cartwright, an English preacher, toward the end of the eighteenth century; but partly because of imperfections in the mechanism and partly because of opposition from the textile industry it made its way very slowly. The idea of dressing the warp with a sizing before placing it in the loom and the invention of a mechanism for taking up the slack of the cloth in weaving—both introduced by William Radcliffe in 1803—made the power loom more practical, and by the year 1815 it was being used generally in the cotton industry, although it was not adopted to any considerable extent in the woolen and worsted industry until about twenty years later. Since then the loom has been improved by the addition of various devices until it has become an almost completely automatic machine of high efficiency. The modern loom stops automatically when a thread breaks or the filling in the shuttles is exhausted, so that it requires practically no attention and involves the use of very little labor.

But while little labor is involved in the weaving of cloth, a good deal is involved in preparing the yarns for the loom. The manner in which yarns are prepared for the loom depends upon whether they are to be used as warp or filling. Warp yarns are wound on spools by means of a machine called a spooler. As many of these spools as there are to be warp threads in the proposed fabric are placed in a large frame, called a creel, where the yarn is unwound from them and wound regularly and evenly on a beam, known as the warp beam. This process is known as warping. Before the warp yarns are placed in the loom they are usually immersed in a sizing solution in order to give them more strength, stiffness and smoothness. In passing through this solution they are unwound from the warp beam and rewound on another beam, known as the weaver's or loom beam. This beam is taken to the drawing-in room, where the threads are drawn through the heddles in the harness frames and through the wire teeth of the reed. The beam and harness are then placed in position in the loom, and the ends of the warp are attached to a roller at the front of the loom, which takes up the cloth according as it is woven. In the meantime, the filling yarns have been wound on bobbins which are placed in the shuttles on the loom. The loom is now ready to start weaving.

The variety of operations performed by a loom in weaving a piece of cloth depends upon the nature of the weave. In the case of a fancy weave, these operations are often bewilderingly intricate, as a large number of harnesses may be used, all of which move up and down in varied groupings and at varied intervals, according to a preconceived pattern. Reduced to its simplest terms, however, the process of weaving may be described briefly as follows: The shuttles fly back and forth, weaving the weft threads over and under the warp threads as the latter are raised and lowered by the harnesses. After each passage of the shuttle the reed is carried forward, pushing the weft thread into place—thus tightening up the weave, so to speak. According as the cloth is woven it is drawn off and rolled by the taking-up roller.

It can easily be understood that the nature of the weave may be



THIS PICTURE OF A TEXTILE MILL INTERIOR GIVES SOME IDEA OF THE SIZE OF THE BUILDINGS AND MACHINERY USED IN CLOTH PRODUCTION.

varied greatly according to the number of harnesses used and according to the groupings in which the harnesses are raised and lowered. While the possible variations in weave are practically unlimited, they may all be classified under six main headings: Plain weaves, twill weaves, satin weaves, figured or fancy weaves, pile weaves and double cloth weaves. Any one of these classifications may include many different qualities of cloth, and any one of them may be varied so as to produce a large number of different effects.

The most important and the most common of all textile weaves is the plain weave, commonly referred to as a one-and-one weave, because the weft or filling thread is passed at right angles over and under alternate warp threads. This produces a smooth, plain cloth of fairly open texture. The closeness of the texture and the smoothness of the surface depend to a large extent upon the size of the yarns used, as well as on the nature of the finish. Woolen cloths, as a rule, are fulled or felted in the finish, so that the texture is not so readily discernible. A variety of patterns can be produced with the plain weave by using yarns of different sizes or dyed yarns of different colors. For instance, corded effects in stripes and checks may be produced by varying the size of the yarns in the warp or weft, or both. Colored stripes are produced by using bands of dyed yarns in the warp, and checks and plaids are produced by using dyed yarn in the warp and filling. Obviously, it is possible by using dyed yarns to obtain an almost unlimited number of different colors. The plain weave is used to a considerable extent in the making of staple woolens, such as broadcloths, homespuns, meltons and kerseys.

The most important worsted weave is the twill weave, of which serge is the outstanding example. It may be distinguished by the fact that it produces fine lines or ribs running diagonally across the cloth. In weaving a twill the filling threads do not pass at right angles over and under the warp threads at regular intervals, as in the plain weave, but at irregular intervals of two, three, four, five or more threads. For instance, the filling threads might pass over one warp thread and under three, four, five or six, or they might pass over two and under one, two, three or four. Every time the filling shuttle goes through

it passes over and under a different set of warp threads. This is what gives the diagonal rib effect. The combinations of this weave can be varied almost indefinitely, so as to produce not only diagonal rib effects but curved, waved and zig-zag ribs, such as herringbones. Additional effects can be introduced, as in the plain weave, by using yarns of different sizes or dyed yarns of different colors.

The satin weave is really a variation of the twill weave, except that it is done in such a way as to conceal the twill structure and produce a very smooth surface. This effect is obtained by passing the filling threads over or under a large number of warp threads—anywhere from six to twelve. If, for example, the filling threads are passed under one warp thread and over eight or ten warp threads, the result is that most of the filling is on the face of the cloth. If, on the other hand, the filling threads are passed over one warp thread and under eight or ten warp threads, the result is that most of the warp is on the face of the cloth. The satin weave is used to a very limited extent in the manufacture of wool goods, except for fabrics like cotton-warp serges, in which only the worsted filling is meant to show on the face of the cloth.

Figured or fancy weaves are the most intricate of all, and are susceptible of endless variations. As the name indicates, they are used to achieve figured patterns on the cloth. The most elaborate and complicated patterns are woven usually on a Jacquard loom, and are often referred to as Jacquard weaves. Brocades are woven in this way. Less intricate patterns are woven on dobby looms, while the more simple patterns, such as stripes and herringbones, are woven on plain looms in plain or twill weaves. The difference between a dobby loom and a plain loom is that the former has a larger number of harnesses, which are operated in a somewhat different way. Also the dobby loom may be equipped with several shuttles, each holding yarn of a different color, the proper shuttle being selected automatically according to the pattern by means of a device known as the box motion.

The pile weave is not, strictly speaking, a separate weave, but is a variation of the plain weave. There are several ways of weaving

a pile fabric, the most common being what is known as the terry motion (from the French *tirer*, meaning to draw or pull). In weaving pile fabrics by the terry motion an extra set of warp threads is introduced. These are left slack in the loom, so that the reed in beating up the filling threads draws the slack warp threads into loops. Subsequently the loops are cut open at the top, or else are left uncut. The same result is sometimes obtained by carrying the extra warp threads across wires laid parallel to the filling threads. Still another method of weaving a pile fabric is by using extra filling threads in the shuttles. These are not carried all the way across the cloth, like the regular filling threads, but are floated to the surface at intervals, making a loose pile.

Finally, pile fabrics may be produced by means of the double-cloth weave. This is done by weaving two cloths on the loom at the same time and combining them into one by interlacing some of the warp and filling threads of one into the other during the process of weaving. When pile fabrics are being made in this way the two cloths are cut apart by a sharp knife as fast as they are woven, leaving a pile on one side of each cloth. The double-cloth weave is used also to produce a double-faced cloth, or a cloth with different patterns on either side, or a heavy cloth with a cheaper material on the back than on the face. In such cases, of course, the cloths are closely interwoven, and are not cut apart subsequently. Pile weaves are not much used for wool goods, the pile effect being obtained usually by a finishing process known as napping. The double-cloth weave is used for beavers, chinchillas and the like.

Chapter IX

Dyeing and Finishing

WHILE variations in weave constitute the chief method of varying the appearance of cloth, there is a wide range of different effects which may be produced by variations in color and finish. Color is applied to wool goods chiefly by dyeing. Printing is used to a very limited extent. Both dyeing and printing mean, in principle, the application of a coloring substance which will combine with the textile in such a manner as to produce a certain shade and remain fast under certain conditions.

Wool differs greatly from cotton in its affinity to dyestuffs. Generally speaking, it takes dyestuffs more readily than cotton. Again, some dyes that will give a good, strong color to wool will give only the faintest tint to cotton and vice versa. The kind of dye used for any given fabric depends upon the effect desired, the conditions under which the fabric is to be used and, finally, the ideas of the dyer as to what is the best dye for these purposes. The variety of dyestuffs used in the wool goods industry, therefore, is practically unlimited. It may be said, however, that a large proportion of them come under the general classification of acid dyes.

Mordant and vat dyes also are used to a considerable extent. A mordant is a substance which has an affinity for both the coloring matter and the textile material, and consequently serves to unite them closely. Tin and chromium are the mordants used chiefly in dyeing wool goods. Mordant dyes, as a rule, are very fast. Vat dyes are so called because they are insoluble in water and must be specially prepared in large vats, where they are made soluble by the addition of some chemical such as hyposulphite. After the material has been dyed the colors must be made insoluble again—or, in other words, fixed—by the addition of other chemicals. These dyes, too, are very fast as a rule.

Wool goods may be dyed either in the raw stock, in the top, in the slubbing, in the yarn or in the piece. The principal reason for dyeing wool before it is spun into yarn is that the coloring matter

penetrates all the fibers more thoroughly and is more likely to remain fast under very trying conditions. For woolen mixtures, the raw wool is dyed immediately after scouring, so that mixed color effects can be obtained in the yarn. For worsteds the dyeing is done for the most part either in the top or the slubbing rather than in the raw stock. The chief reason for dyeing yarns is to permit the achievement of woven color effects. Cotton warp goods also are dyed usually in the yarn, because the cotton and wool take the color differently.

For all solid colored goods piece dyeing is the cheapest and most convenient method. Piece-dyed goods are woven with yarns in their natural colors and then are passed over rollers through vats containing the dye liquor. Cross dyeing and speck dyeing are variations of the piece-dyeing method. The former is used for cotton warp goods which have been woven with undyed wool yarns. Such goods are woven usually with colored cotton yarns and white wool yarns. They are then piece dyed in a stuff that will color the wool without affecting the cotton. Speck dyeing is done to goods which contain burrs. If wool contains a large amount of burrs they are removed, before the wool is carded or combed, by a chemical process known as carbonizing, described in a previous chapter. Otherwise they are picked out. But sometimes, when the wool is not carbonized, a number of burrs remain which are too deeply imbedded in the fiber to be picked out without injury to the fiber. These, being vegetable matter, take the dye differently than wool and cause specks in the cloth. When this happens the cloth, after the regular dyeing, is treated to another dye that will color the burrs without affecting the wool.

All dyeing is done by soaking the material to be dyed in the coloring liquid. Subsequently the material is rinsed and dried. Printing is used instead of dyeing as a more convenient method of applying designs in color. Colored designs on cloth, as we have already seen, can be obtained by weaving yarns of different colors and, thanks to the Jacquard loom, very intricate designs may be achieved in this way. But the printing method is much more simple.

By this method a series of rollers are engraved with the proposed design. There is a separate roller for each color, engraved only with the part of the design which carries that particular color. The coloring matter applied to each roller is scraped off with a close-fitting knife as fast as the roller revolves, remaining only in the engraved parts. The cloth is passed over these rollers by means of a revolving cylinder, receiving the color impressions as it passes. Printing is not used very much for wool goods. In making certain kinds of worsteds, however, the combed sliver is sometimes printed before it is twisted into yarn. This is known as vigoureux printing.

If the natural color of the wool is not a clean white, or if the wool has acquired stains in the preliminary manufacturing processes, it must often be submitted to a bleaching process. This is especially true if the goods are to be finished white or dyed in light colors. Wool usually is bleached with sulphurous acid. The general method is to pass it in a damp state through a closed chamber filled with the fumes from burning sulphur. Sulphurous acid apparently does not destroy the coloring matter in the textile, but simply changes it to white, so that a cloth bleached in this way may eventually revert to its original color. Consequently it is not an ideal bleach for white goods. Oxygen, on the other hand, destroys the coloring matter entirely, and for this reason some oxygen agent, such as hydrogen peroxide, sodium peroxide or potassium permanganate, often is used instead of sulphurous acid.

In addition to bleaching and dyeing, wool goods must be put through a number of other finishing processes. The nature of these processes, of course, depends to a large extent on the nature of the finish desired. Generally all wool goods are divided, according to finish, into clear-finished goods and face-finished goods. Clear-finished goods are those which receive little or no fulling, and which therefore show the texture clearly. Most worsteds come in this class. Face-finished goods are those which are fulled so that the texture of the cloth is not apparent. Broadcloth is a typical example of the latter. But whether the cloth is to be fulled or not, it goes first through the processes of perching, burling and mending.

DRAWING WARP THREADS THROUGH THE HEDDLES IN THE HARNESSES, WHICH CONTROL THE APPEARANCE OF THE WEAVE, AS THEY MOVE UP AND DOWN ACCORDING TO THE PATTERN

Perching is really a method of inspection. The perch consists of two horizontal rollers about four feet apart, suspended from the ceiling near a window. The cloth is stretched over these rollers and the inspector stands between them, so that he can pull down the cloth bit by bit and examine it against the light for defects. These defects are marked with chalk, and the cloth then goes to the burlers, who spread it out on stands and remove knots, bunches and loose threads by means of burling irons and scissors. Any defects which may have escaped the inspector are likely to be discovered by the burlers and these, too, are marked with chalk for the menders. Fine cloth usually is submitted to an additional inspection after the burlers get through with it. Then it goes to the menders, who repair any remediable defects by darning. In case the goods are not to be fulled they are then singed, in order to remove any fuzz which may appear on the surface. Subsequently the goods are scoured, in order to remove the oil with which the wool was treated before spinning, the sizing applied to the warp before weaving, and any other foreign matter which the fabric may have acquired during the process of manufacture. Sometimes, however, this scouring is omitted, as a certain amount of scouring is included in the fulling process.

Fulling is a process peculiar to the wool industry, and it owes its origin to the characteristic felting or matting quality of the wool fiber. The wool fiber is covered with minute scales, so that when a number of fibers are pressed together they tend to interlock. This interlocking is intensified by the application of moisture and heat, which causes the fibers to shrink. Fulling is merely a process by which the fibers in a piece of cloth are made to mat or felt by the application of moisture, pressure and heat. Obviously, it gives the fabric greater strength and body, and this is primarily the purpose for which it is used. It is used, too, to give the fabric a certain characteristic feel and appearance. Also, unfortunately, it may be used to give good body, feel and appearance to inferior fabrics and to cover up defects in the texture.

The fulling process consists of saturating the cloth with hot water and soap and passing it between slowly revolving rollers.

Heat is generated by the friction of the rollers. The cloth may remain in the fulling mill anywhere from two to eighteen hours, depending upon the amount of fulling required. Worsteds receive comparatively little fulling, whereas broadcloths, or cloths which are to get a napped finish, are very closely fulled. Cloth will shrink in this process anywhere from 10 to 25 per cent, according to the amount of fulling it receives.

In order to make up for this shrinkage, and also in order to lend body to inferior goods, flocks are sometimes fulled into the goods. Flocks are small bits of wool fiber obtained either by shearing the nap off goods in the finishing room or else by cutting up or grinding up rags. When they are employed to obtain a closer felt in goods of sound quality their use is not open to criticism; but when they are used to give body and the appearance of superior wearing quality to inferior fabrics, they are, of course, misleading, since they do not add to the wearing quality of cloth. Their presence in a piece of cloth may be detected by brushing the back of it vigorously with a stiff brush. Some of them will come out in the brushing.

After the fulling has been completed the goods are washed, stretched and dried. Subsequently some goods, chiefly dress goods, are put through a process known as crabbing, the purpose of which is to set the goods. In the crabbing process the cloth is wound tight on a cylinder which revolves in hot water. Then it is taken out for one or two hours, after which it is returned to the machine for about twenty-five minutes, during which it is boiled and pressed. Next comes the process of gigging or napping. The cloth in a tightly stretched condition is passed over revolving cylinders equipped with teasels or wire teeth which scratch up the short fibers to the surface and produce a nap. The teasels used in the gigging machine are the dried flower heads of a plant of that name, and are about the shape of pine cones. Strictly speaking, the term gigging is applied only to the process of raising a nap with the teasel gig, while the term napping refers to the process of raising a nap with the wire-toothed napping machine. The teasel gig is generally considered superior to the napping machine for this purpose.

The amount of napping given to the cloth depends upon the kind of finish required. Some get a superficial napping and some a deep napping. Where a very soft nap is required, the cloth may be put through the gig or napping machine several times, part of the nap being cropped or sheared after each napping. After the napping is completed the nap is brushed up and sheared to make it even. If a smooth, lustrous finish is desired, the cloth is pressed between heated calender rollers, and subsequently steam is forced through it at high pressure. This process is applied chiefly to men's wear goods. Women's wear goods usually get a water finish. This consists of brushing the face of the goods with water by means of a machine known as a wet gig, after which they are stretched and pressed. There are various other kinds of special finishes used for different kinds of goods. They are too numerous to be described here. But in general, the processes already described are those applied to the great majority of woolen and worsted fabrics.

Before the cloth is ready for shipment it is subjected to a final inspection for defects. All remediable defects are then remedied, and the cloth is marked firsts or seconds, according to the number of defects it contains. There is no hard and fast rule as to what constitutes firsts and seconds. Every manufacturer has his own standard. But on the average six defects are allowed in a piece of goods classifiable as firsts, while a piece containing more than six defects is classified as seconds. Subsequent to this final inspection the goods are measured, rolled and packed for shipment.

Chapter X

Manufacture and Use of Shoddy

SHODDY is a term so widely used and misused that the average person, even the average wool goods buyer, has a very loose notion of what it really is. But for a long time the question of shoddy versus virgin wool has been the subject of so much discussion and agitation in the public prints and the halls of Congress that a clear understanding of the meaning of the term has become important. Especially is it important for the buyer and user of wool goods to know in what way the use of shoddy impairs the wearing quality of a fabric.

Originally, shoddy means anything that is shod or shed, and, strictly speaking, it covers all wool fibers that are shed in the process of manufacture. Thus it would properly include noils and the various forms of waste broken off by or entangled in the combing, drawing and spinning machinery. In modern trade usage, however, the term shoddy is used to describe reworked wool; that is to say, wool which previously has been manufactured into yarns or fabrics. Virgin wool, on the other hand, is wool which never has been submitted to any manufacturing process.

Obviously, there are many different grades of shoddy, according to the variety and quality of the stock from which it has been reworked. Contrary to a widespread impression, fostered by the propaganda of those who, for one reason or another, are opposed to the use of shoddy, it is not a product obtained by grinding up an indiscriminate mass of rags. The raw material of shoddy consists of waste yarns, clippings of new wool fabrics gathered in mills and clothing factories and old wool rags. Shoddy obtained from very hard woven woolens and worsteds is inferior to that obtained from soft woven or knit goods—everything else being equal—and it is often referred to as mungo. Shoddy obtained by untwisting waste yarns or yarns from knit goods is often referred to as garnetted stock.

All the materials from which shoddy is made are sorted according to the quality of the fiber that may be obtained from them. Roughly speaking, four conditions are observed in the sorting: The purity of the material, the length of the fiber, the structure of the weave and the color. The purity of the material refers to whether it is all pure, virgin wool or contains a percentage of reworked wool, cotton or silk. The length of fiber is an important consideration because it helps to determine the quality of wool in the material. The structure of the weave is important because a loosely spun and loosely woven material is easier to rework without injury to the fiber than a hard-woven or felted material. Finally, the colors have to be considered because some of them are fast and some will fade in the process of reworking; some of the materials can be redyed and some cannot.

Generally speaking, the best materials for reworking are knit goods, all wool merinos, worsteds, serges and flannels—in about the order named. Most of these are made exclusively from virgin wool of good quality, and none of them will contain more than a small percentage of shoddy. Next in value come woolen cloths, jerseys, cloakings and felted woolens. These will contain a considerable percentage of reworked wool, and some of them a large percentage. In the lowest category are included unions, delaines and carpets. These classifications, of course, are modified according to whether the materials are new or old and according to the kind of fiber used in them.

Shoddy materials are sorted according to grade by dealers who make a specialty of this work, and are sold in graded lots to converters. The converter is the man who turns them into fiber suitable for spinning and weaving. The different processes used in the conversion of these materials are known as carbonizing; baking and dusting; washing, stripping and dyeing; conditioning; picking and shredding. These processes vary somewhat in different plants; but in general, the progress of the materials through the converting plant may be described as follows:

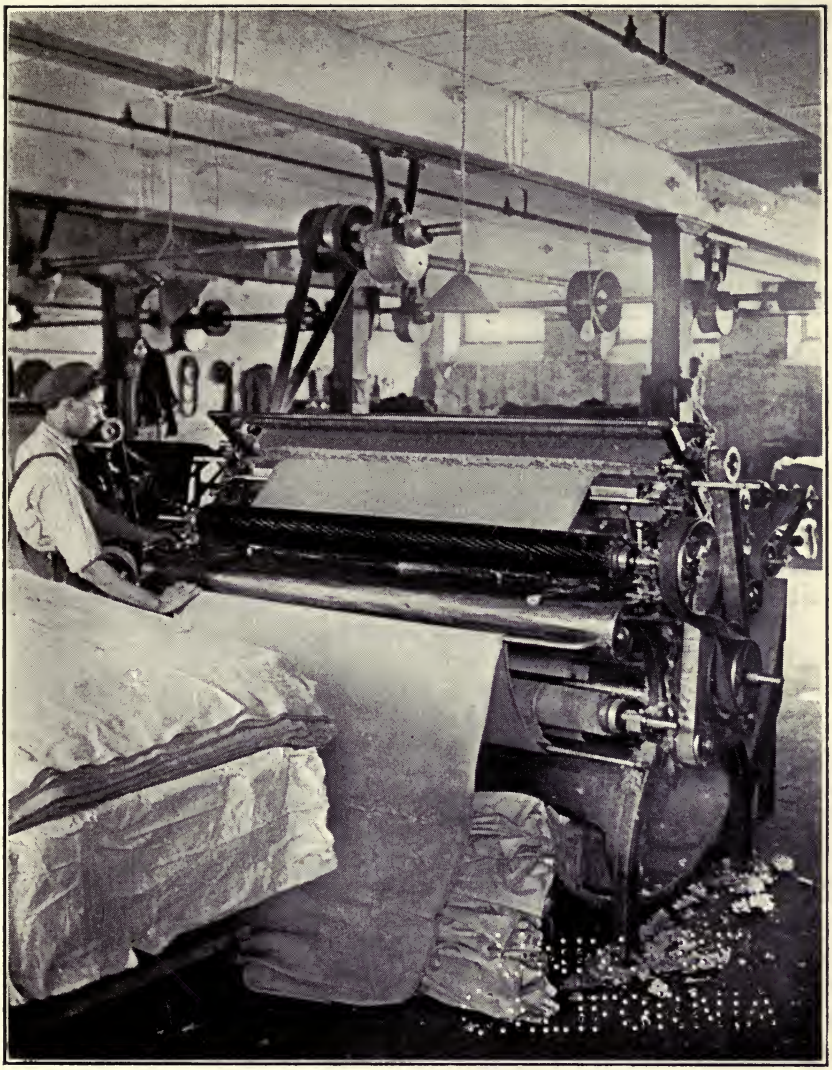
After being cleaned, wherever necessary to remove dirt or grease,

the materials are subjected to a chemical bath in order to disintegrate the cotton or silk which may be mixed with the wool. In the case of cotton fiber, which is most often present, the carbon in the cotton is released by the application of an acid, and the process consequently is known as carbonizing. The chemicals generally used are sulphuric acid, hydrochloric acid, or bisulphate of soda. In the case of a silk mixture, a caustic alkali is used. The percentage of silk-mixed wool fabrics, however, is very small.

After carbonizing, the acid which the materials have absorbed is removed by means of a centrifugal machine known as a whizzer. The materials are then baked at a very high temperature, which reduces the carbonized cotton to a condition of dust, and this dust is taken out by a machine known as a duster, or willow. Subsequently, the materials are washed in a mild solution of soda ash in order to neutralize whatever acid may remain in them. This washing has the further effect of removing any dirt or dust that may be left after willowing. The materials then are wrung out and dried at a moderate temperature.

By this time the fugitive colors have been faded by the acid bath and the baking. So it is necessary to sort out the faded materials and further reduce the color in them so that they can be redyed to uniform shades. This reducing process is known as stripping and is accomplished by the application of a chemical. Soda hydralite, bichromate of potash and sulphuric or oxalic acid are most generally used for this purpose. The materials then are dyed in the usual manner. White and fast-dyed materials, of course, do not need stripping or dyeing.

The next process in the conversion of shoddy is known as conditioning. It consists of lubricating the fibers so as to make them soft and supple, and consequently in better condition for carding and spinning. The materials are spread out in thin layers, sprinkled liberally with oil or an oil emulsion, and left to soak for twenty-four to forty-eight hours. The materials now are loose and pliable, free from foreign matter, and ready to be teazed out or shredded. This is done by a picking machine similar to that used on raw cotton or



CLOSE-UP OF A SHEARING MACHINE IN A GREAT WOOLEN ESTABLISHMENT. NOTE THE PILES OF CLOTH WHERE IT HAS LEFT THE MACHINE

[illegible]

raw wool. Sometimes, the process of shredding is carried further by putting the materials through a carding machine, known in the shoddy industry as a garnetting machine.

All the processes to which shoddy is subjected are the same as those used in the preparation of virgin wool, except that the virgin wool is scoured and does not have to be stripped before dyeing. After the shoddy has come through the picking and garnetting processes it is all pure wool fiber, varying in length and strength according to the material from which it has been recovered and the extent to which this material has previously been worn. The shoddy now is in a spinnable state. Usually it is mixed with virgin wool before being spun into yarn; but sometimes it is mixed with cotton and sometimes it is spun into yarn without being mixed with any other material.

The quality of a shoddy fabric depends, as already remarked, upon the grade of shoddy used, the grade of virgin wool used, the percentage of shoddy to virgin wool in the fabric and the skill with which the manufacturer manipulates the shoddy. Because of the shortness of fiber it is difficult to work shoddy satisfactorily, but by careful experimentation many mills have overcome the technical difficulties of manipulating shoddy and are able to produce shoddy materials that compare favorably with the best materials made from virgin wool.

Of course it is important to remember that a given grade of shoddy is not by any means as valuable as a corresponding grade of virgin wool. But it is important also to remember that the amount of shoddy or virgin wool in a fabric does not of itself indicate the quality of the fabric, since some grades of shoddy are very much superior to some grades of virgin wool. Experiments conducted some time ago with three grades of wool by the Bureau of Standards of the U. S. Department of Commerce demonstrated the fact that a fabric made from reworked wool of the first grade was superior to a fabric made from virgin wool of the second grade and very much superior to a fabric made from virgin wool of the third grade. It was demonstrated also that wool of the first grade could

be reworked four or five times before it would be as low in quality as virgin wool of the third grade.

As to the amount of shoddy consumed in this country, opinions differ. The most reliable estimates indicate that about 20 per cent of the wool fiber used by the domestic woolen and worsted industries is shoddy. Practically all of this is consumed by the woolen industry. The amount of shoddy consumed by the worsted industry is little more than one per cent. The lower grades of shoddy are used to a very slight extent in the United States.

Shoddy is used for the most part in felted woolens and blankets. Some overcoatings, such as meltons and chinchillas, are made largely or entirely of shoddy, and some of these have excellent appearance and wearing quality. It is unquestionable that many shoddy fabrics are practically worthless, and that shoddy is used sometimes by unscrupulous manufacturers to make an inferior fabric which can be palmed off on unwary buyers as a good one. But as a rule shoddy is used legitimately to make a good, warm, durable fabric which can be sold at a much lower price than a fabric of equal quality made altogether from virgin wool. On this subject a special report on the shoddy industry of England and France, published some years ago by the Department of Commerce, makes the following comment:

"A hundred years ago, wool waste and old rags were disposed of by burning or by being used as fertilizers; but now they enter largely into the clothing requirements of the world, and by their cheapening effect have done much to popularize woolen clothing for the masses. The increasing use of waste materials and of the by-products of manufacture is a sign of the increasing economic efficiency of mankind, and as the world is rapidly becoming more and more crowded, the economic use of all available fibers will become of more and more importance."

Chapter XI

Mohair, Alpaca and Other Fibers

WHILE wool generally is understood to mean the hair of sheep it has a much wider meaning scientifically. Strictly speaking, all animals are provided with a covering either of feathers or of hair. There are various kinds of hair, such as bristle hair, beard hair and wool hair. Beard hair is the main covering of aboriginal sheep and goats. In addition to beard hair, these animals have a certain amount of soft, downy hair, or wool hair, and by careful breeding through many generations, as in the case of domesticated sheep, this wool hair has been developed until it has supplanted the beard hair largely or altogether.

In chemical composition wool hair and true hair are alike; but they have certain physical differences. The essential difference is that wool hair, viewed microscopically, is covered with a number of miniature scales, while these scales are lacking in true hair. All scaly hairs, therefore, are strictly classifiable as wool. In addition to the hair of domesticated sheep, this classification includes the hair of certain goats, of camels and dromedaries, and of a species of South American animal known scientifically as *auchenia* and popularly as camel sheep.

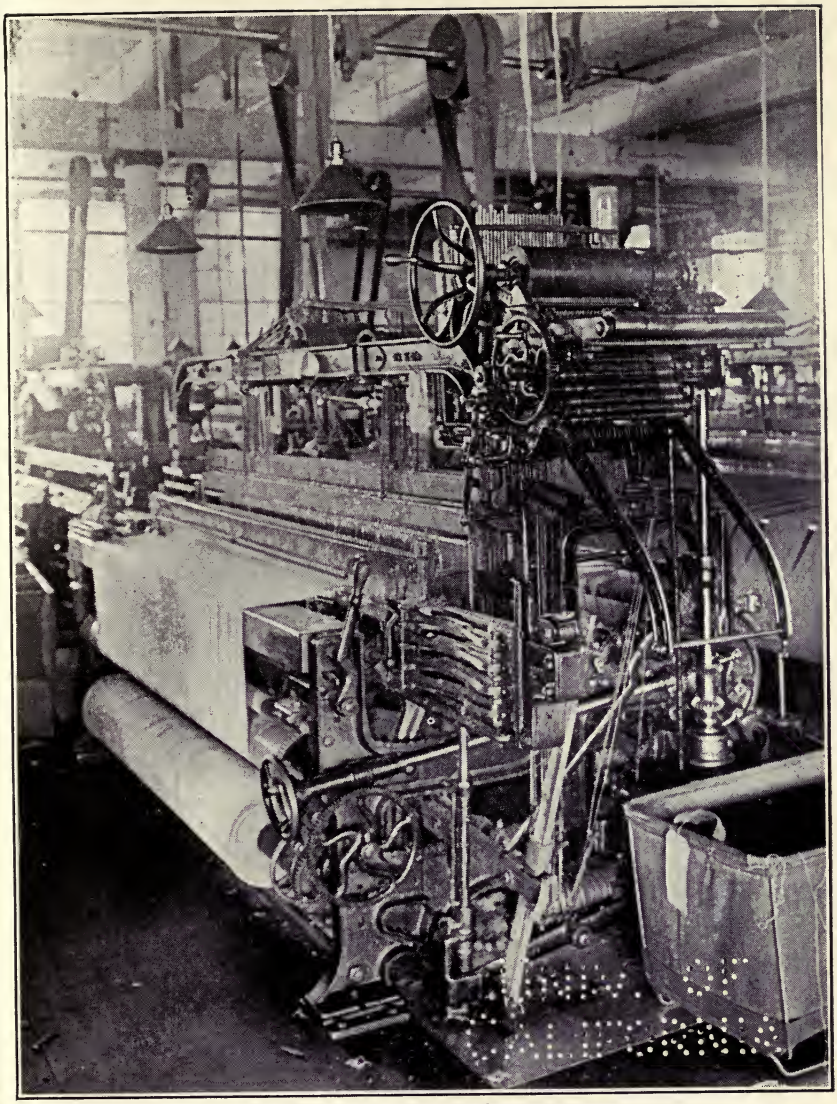
The wool of sheep differs from the wool of other animals in the same classification chiefly by the fact that it is more wavy and that the scales on the fiber have distinctly raised or serrated edges, whereas in the wool of other animals the scales tend to fit smoothly into one another, with comparatively slight serrations or no perceptible serrations at all. This distinction, of course, is not exact, since certain kinds of sheep's wool, such as the luster wools from pure bred Lincolns and Leicesters, approach in character the wools of the goat family, just as some of the latter are virtually indistinguishable from true hair.

Generally, however, it may be said that sheep's wool is more wavy and serrated than other wools, and it is these qualities which

give it its superior value for textile purposes. Next in value come the wools of certain cultivated varieties of goat, chiefly the Angora, Cashmere and Thibet goats. Apparently, goat's hair has been used for textile purposes from very ancient times. We find it among the materials which Moses commanded his followers to take with them in the flight from Egypt, and we learn from Exodus (XXXVI, 14) that "the wise workmen wove eleven curtains of goat wool, thirty ells long, four ells broad, all of the same size." In later times, as we gather from Aristotle and other ancient writers, goats were cultivated expressly for their wool, notably in that part of Asia Minor known as Phrygia.

The ancient Phrygia included the modern Turkish province of Angora, which has become famous as the home of the Angora or mohair goat. Fabrics made from mohair were introduced to Western Europe during the sixteenth century and grew so steadily in popularity that the Turkish Government, in order to retain a monopoly of this valuable trade, forbade the export of raw mohair, or *tiftik*, as it is called in Turkey. This embargo was maintained until 1820, when it was lifted through the influence of the British Government. During the ensuing years the manufacture of mohair fabrics became an important industry in Western Europe, and the increasing demand for mohair led to the crossing of the original pure Angora with the common Kurd goat.

As a result, the production of mohair spread from the province of Angora throughout Asia Minor generally, and was introduced into Cape Colony, Australia, South America and the United States. At the present time Asia Minor and Cape Colony are the two chief sources of the world's supply of mohair. The United States is next in importance, although its production is not nearly sufficient for the needs of the domestic industry. American mohair, on the whole, is inferior to the foreign product, because it contains a larger amount of kempy fiber (beard hairs) which will not dye, and because most of it must be shorn twice a year, so that it is shorter in staple. Texas produces the finest fleeces, but unfortunately the wool of Texas Angora tends to fall off if it is allowed to grow an entire



Close-Up of a Loom in a Big Weaving Mill, Showing the Woven Cloth Being Wound on the Roller at Bottom, as It Is Finished

year, and consequently it must be shorn before it has reached its full length. Oregon fleeces grow for a full year and are very long in staple, but are not as fine as the best Texas grades.

Mohair is a hard, fine fiber, of very long staple (sometimes as long as 12 inches), with a high, silky luster and with little or no curl. It is of a hard, wiry nature; the scales on its surface are thin and flat, and it will not felt to any considerable extent. Length and luster are the chief considerations in judging its value. The natural color of mohair is a pure white, but sometimes it is gray. It does not take dyes as readily as sheep's wool, and dyestuffs, furthermore, are apt to give it a harsher feel. The finest mohair dress goods, therefore, usually are woven with undyed mohair filling and dyed cotton warp. Mohair is used for plushes and other upholstery fabrics, imitation furs, dress goods, summer suits for men, carriage robes, rugs, braids and various other purposes.

Cashmere wool is obtained from the Cashmere goat, a small, elegant animal bred from very ancient times in the Himalayas. The term, however, is used generally to include also the wool of the Thibet goat. The latter is a larger and stronger animal than the genuine Cashmere goat, but produces a wool that is somewhat similar in nature, although not so fine and beautiful. It is sometimes referred to as the Thibet Angora. Cashmere wool is comparatively short in staple (1¼ to 3½ inches) and has visible scales with fairly pronounced serrations. Its spinning and felting qualities, therefore, are somewhat akin to those of pure merino wool. It is used for fine Oriental shawls (Cashmere shawls) and for fine fabrics requiring a very soft nap.

The species of animals known as the *auchenia,* or camel sheep, include the *auchenia paco* (or alpaca), the *auchenia llama* and the *auchenia vicuna,* all of which are native to the South American Cordilleras. The name alpaca is applied commonly to the wool from both the *auchenia paco* and the *auchenia llama,* although strictly it is applicable only to the former. The llama is a wild goat about the size of a deer and produces a long, coarse and inelastic wool of a white or brown color. The true alpaca is obtained from the domesti-

cated *auchenia paco.* It averages about 6 to 8 inches in staple, is slightly wavy, has very faint serrations and is rather fine in feel. The natural colors are white, red, brown and black. Alpaca is used for linings, summer suits and dress goods. Alpaca dress goods have a cotton warp and alpaca filling.

The *auchenia vicuna* is a wild goat about the size of a sheep. It is now very rare, and little true vicuna wool is obtainable. The genuine vicuna is a fine, silky wool with a high luster, a beautiful reddish brown color and considerable felting quality. Commercially, the term vicuna is used to describe a yarn spun from a mixture of sheep's wool and cotton or an all-cotton yarn finished in imitation of a woolen yarn (often referred to as vigogne yarn). It is used also to mean a slightly napped fabric made of soft wool, sometimes mixed with cotton, in imitation of a genuine vicuna fabric.

Camel hair is obtained from the camel or the dromedary. It is a very fine, rather curly hair, of great strength and softness, averaging about 4 inches in staple. Its natural color is yellow, red or brown. It is used either alone or mixed with sheep's wool for natural color camel cloth, dress goods, shawls, hosiery, blankets, carpets, felt hats and other purposes. The camel hair cloth of commerce is not always made from genuine camel's hair, as the name is used to mean a fine, soft dress fabric, with a glossy and slightly hairy finish, made from long staple sheep's wool.

Various true hairs, such as those of the cow and the horse, are used to a limited extent for textile purposes. Cow hair (mostly from Siberia) often is employed in the coarser carpets, blankets and cheap felted goods. Horsehair cloth is used for upholstery, as stiffening and underlining for coats and for other purposes. But true hair has little value as a textile material, since it lacks the scaly surface of wool hair and the fibers consequently will not hold together when twisted into yarn. Thus, horsehair must be glued to a binding thread of cotton or hemp before it can be spun, and cow hair must be mixed with wool. In fact, the hair cloth of commerce has usually a warp of cotton, linen or worsted, and a weft consisting of single horsehairs (from the mane or tail) which have not been

twisted into yarn. Sometimes it is made altogether from hard-spun cotton yarns treated with a heavy sizing in imitation of real horsehair.

Many attempts have been made to produce artificially a fiber with the characteristic qualities of wool. The most common method of doing this is to treat vegetable fibers, such as jute and dha (Senegalese hemp), with certain chemicals which give them the physical appearance of the wool fiber. Another method is to dissolve the fibers recovered from old rags and to evolve threads from the resulting solution—a process similar to that used for making artificial silk. But none of the substitutes for natural wool has any particular value and their commercial importance is of the slightest.

Chapter XII

Dictionary of Wool Fabrics

IN the strict sense, it is impossible to define exactly what constitutes any given woolen or worsted fabric. This is true even of the most familiar staples, such as tweeds or serges. The nature of even such staples varies greatly according to the kind of raw material used, the manner in which the raw materials are blended, and the skill, care and equipment employed in the manufacturing processes. One mill may make a handsome and durable fabric out of low grade stock, while another may make an inferior fabric out of comparatively high-grade stock.

When it comes to fancies, of course, the variety of results is much greater. A modern loom is like a chess board, on which the possible combinations of moves are almost unlimited. If one adds to these variations in weave the innumerable variations obtainable in yarns, colors and finishing processes, it can easily be imagined that the different results obtainable are beyond count. As a matter of fact, every season sees a flood of novelty fabrics. Some of these find a limited acceptance, some of them last for a season or two, while some of them win a permanent place and eventually become staples.

Naturally it would be impracticable to compile a comprehensive dictionary of such fabrics, and for this reason the following list attempts to include only the most familiar staples. Even these, as we have remarked, are susceptible of unlimited variations. But generally speaking, every staple fabric has certain typical characteristics, and it is merely these typical characteristics which the ensuing descriptions attempt to define.

Widths and weights are not given, since these, too, may vary a good deal in any given fabric. But, as a rule, dress fabrics weigh from 8 to 14 ounces to the yard and measure 54 to 56 inches in width. Coatings may weigh anywhere from 16 to 36 ounces to the yard.

ASTRACHAN. A woolen fabric with a curled pile, made in imitation of astrachan fur. The best grades are woven, while the in-

ferior grades are knitted. The woven fabric is made with a warp pile, obtained by running a set of warp threads over wires (see **PILE FABRICS**). The warp yarns used for the pile usually are either luster wool or mohair, while the ground warp may be either cotton or wool. Woolen yarns, very often spun from mill waste, are used for the filling. After it leaves the loom the fabric is crabbed, scoured, dyed and finished without pressing. The cheaper grades are woven without a pile and get a napped finish. Astrachan is used for coats and trimmings.

BANNOCKBURN. (See **TWEED.**)

BEAVER. A soft, heavy woolen fabric napped on the face or on both sides. It is made either with a plain weave, using one set of hard-twist warp yarns and two sets of filling yarns, or else with a double-cloth weave. For the yarns which show on the face, it is customary to use a fine wool of good felting quality, such as Australian merino or Ohio fine delaine. These yarns are spun to fine counts. After it leaves the loom the fabric is closely felted, wet napped on one or both sides, shorn, steamed, dyed, wet brushed, shorn again to even the nap, and pressed. It is used for overcoats.

BEDFORD CORDS. A strong, heavy woolen fabric with a warpwise cord. The warp yarns are either single or two-ply, and are spun with a hard twist from fine crossbred wool of long staple. The fabric may be dyed either in the yarn or the piece. It is finished by being fulled, steam brushed, closely shorn and pressed. It is used mostly for sports skirts and costumes.

BROADCLOTH. There are so many different qualities and weights of this fabric that it is difficult to define. Generally it may be described as a fine, full-bodied woolen cloth with a very smooth finish. Sometimes it is made with a worsted warp. The filling for the better qualities is spun from fine wool of good felting property, such as Ohio delaine or Australian merino, while for the medium qualities merino noils or fine shoddy may be used. Since the fabric is thoroughly fulled an inferior cloth of deceptively good appearance may be made with low grade wool or shoddy. Broadcloth is plain woven, and after leaving the loom it is well fulled, napped,

closely shorn, steamed, pressed and dyed. Subsequently it is wet brushed, shorn again, and again steamed and pressed. It is used for suits and coats.

CASSIMERE. A twilled woolen or worsted fabric made in a variety of weights, qualities and designs. Many different grades of wool, waste and shoddy are used in its composition. As a rule it is closely woven from hard-spun yarns and receives what is known as a clear finish, or, in other words, a finish which does not obscure the weave. This consists of a light, dry napping and a close shearing. Subsequently, the fabric is brushed, sprayed and heavily pressed. It is used mostly for men's suits.

CHEVIOT. A rough, coarse, twilled woolen fabric, originally made from the coarse, curly wool of the Cheviot sheep, whence it gets its name. Nowadays, it is made usually from crossbred wool, and in the lower grades it is likely to be heavily adulterated with cotton, shoddy and flocks. As a rule it is made with warp and filling yarns of contrasting colors, and novelty yarns (q. v.) are used sometimes to produce special effects. The yarns are spun from wool dyed in the raw stock. Cheviot is closely fulled and is finished with a rather thick, curly nap. It is lightly sheared to even the nap and subsequently is steamed. It is used for suits, coats and dresses.

CHINCHILLA. A soft, heavy woolen fabric with a curled pile. It is loosely woven, generally as a double cloth; but sometimes as a three-ply cloth. As a rule, it is felted and wet napped, but some fine chinchillas are made with a long pile formed by floats of filling thread, and are not felted. The distinguishing feature of chinchilla is the close curl given to the pile in the finishing process. This is done by means of a special machine. In this machine the fabric is pressed between two flat surfaces, of which the lower one is stationary while the upper one moves with a rotary motion, rubbing the pile into little curly nubs. Chinchillas seldom are shorn or pressed, although a slight shearing may be necessary sometimes to even the pile. They are made usually in solid colors, or with fancy backs from stock-dyed wool. They are used for overcoatings.

CLAY WORSTEDS. (See **WORSTEDS.**)

COVERT CLOTH. This name commonly is applied to a class of woolen fabrics which are properly described as venetians (see **VENETIAN**). The genuine covert cloth is made with a twill weave from ply yarns of mixed colors. The yarns are mule-spun from dyed wool of fine quality, and two yarns of different colors are twisted together for the warp, while two-ply or single yarns of one color are used for the filling. The color of the filling yarns corresponds, as a rule, to the darker color of the mixed warp yarns. Covert cloth receives a clear finish. It is lightly fulled and napped, closely sheared, brushed, sprayed and pressed. It is used for coats and dresses—chiefly sports costumes.

CREPE. A soft, drapy fabric with a crinkled surface. As a rule the crêpe effect is produced by using yarns with an extra twist, which makes them crumple up when they are unwound off the bobbins in the weaving. Crêpe yarns have twice or three times the amount of twist given to yarns for other fabrics. Sometimes the crêpe yarns are given both a regular and reverse twist. Occasionally the crêpe effect is produced by means of a fancy twill weave. Crêpes are made in a variety of weights and qualities, and with either woolen or worsted yarns. After coming from the loom they are crabbed, piece-dyed, brushed, sheared and pressed. Crêpe is a dress fabric.

DUVETYN. A soft, twilled fabric with a fine, silky nap. It is made, as a rule, with single or two-ply worsted yarns for warp and mixed wool and waste silk or tussah yarns for filling. Some duvetyns have an all-woolen filling, while some are made entirely of silk. The latter are properly described as all-silk duvetyns. The regular duvetyn has a good, long-staple crossbred wool for warp and a fine, soft, merino wool mixed with waste silk for filling. It is stock-dyed. After being fulled it is wet napped, wet brushed, shorn to even the nap, steamed, tentered, dried and brushed. It is used for coats and dresses.

EPONGE. A soft, spongy cloth, made with novelty yarns of coarse sizes. (See **NOVELTY YARNS.**) As a rule it has either a novelty yarn warp and plain filling or a plain warp and novelty

yarn filling. It is woven with a plain weave, and may be either stock- or piece-dyed. It receives practically no finishing, except for a slight shearing. Eponge is used for dresses, trimming and drapery.

See RATINÉ.

FRIEZE. A coarse, heavy, harsh-feeling woolen fabric with an irregular nap. The name was applied originally to a rough fabric made in Friesland, and later came to be identified with an overcoating fabric made in Ireland from coarse native wool. Ordinarily, frieze is made from coarse wool, wool waste and shoddy. The lower grades contain a very large percentage of shoddy. It is dyed in the stock, woven with a plain or twill weave, well fulled, napped, sheared and pressed. It is used for overcoats.

GABARDINE. A strong worsted fabric made with a twill weave, and showing fine, diagonal cords. The better grades have a hard-spun two-ply warp and a coarser two-ply filling, while the lower grades have a two-ply warp and coarse single filling. As a rule, it is very closely woven, showing about twice as many warp yarns as filling yarns to the inch. After coming from the loom it is scoured, crabbed, dyed, brushed, sheared, brushed again, sprayed and pressed. Gabardine is used for suits and dresses, and also, to a large extent, for raincoats. For the latter purpose the fabric must be waterproofed. There are many different processes for waterproofing fabrics, most of which are patented and confined to individual manufacturers. Among the substances used are rubber, wax, oils, varnishes, acids, oxides and metallic salts.

HOMESPUN. The original homespun, as the name implies, was made from yarns spun on the old spinning wheel. Such yarns were rough and irregular, and the fabric woven from them had, consequently, a rough, nubby appearance. The homespun familiar to commerce is an imitation of the original article. The yarns are spun into coarse sizes from medium-grade wool of fairly long staple, which is dyed in the stock and blended to produce mixed color effects in the yarn. Sometimes camel's hair tops, mohair or alpaca are blended in with the wool. The weave may be either plain or twill. After leaving the loom, the fabric is fulled, washed, dried and

When You Look at This Machinery, a Very Small Part of That Used in a Woolen Mill, You Get an Idea of the Amount of Money It Takes to Swing a Textile Enterprise

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brushed, lightly sheared, steamed and pressed. Homespun is used for suits and dresses.

KERSEY. A strong, smooth fabric somewhat similar to broadcloth, except that it is much heavier. Originally, in fact, the name described simply an inferior grade of broadcloth. The filling yarns in kerseys are spun usually from fine wool of good felting quality, merino noils or fine shoddy being most often used. The fabric is woven, as a rule, with a twill weave, and often it is woven as a double cloth. It is very thoroughly fulled, wet napped, sheared, brushed and dyed. Then it is dried, brushed again, steamed, sheared again, brushed once more, sprayed and pressed. It may receive either a dull or a lustrous finish, the latter being obtained by a heavy, hot pressing. Like all closely fulled fabrics kersey may contain a large proportion of low grade shoddy and flocks. It is used mostly for coats.

MACKINAW. A soft, heavy woolen cloth, usually napped on both sides and made up in fancy plaids in high colors. The name was applied originally to the heavy, colored blankets purchased by the Indians of the Great Lakes region from Fort Mackinaw, which was then the most remote trading post in that territory. Later the cloth was used for coats by lumbermen and hunters in Michigan, and eventually it became generally popular for winter sports wear. It comes in many different qualities. Usually it is made altogether from coarse wool or a mixture of coarse wool and shoddy. Sometimes it is made with a cotton warp and a shoddy or wool waste filling. The yarns used are soft and heavy. It is thoroughly fulled, scoured, napped on both sides and sometimes waterproofed. When it is woven as a double cloth—as is frequently the case—it receives only a slight fulling.

MELTON. A strong, heavy, semi-finished woolen fabric, used chiefly for overcoats. The stock used for making meltons, as a rule, is a mixture of medium-staple crossbred wool and short-staple fine wool or fine merino noils. The heavy weights are woven usually with a double warp, while the lighter weights sometimes have a cot-

ton warp. It is heavily fulled, napped on the face and closely shorn to show the texture.

MONTAGNAC. A soft, fleecy fabric with a thick, curly nap. It is made with a twill weave from fine, soft wool. After leaving the loom it is fulled, washed, napped, cropped to even the nap, and dried. Then it is put through a whipping machine, which makes the nap stand up straight. Subsequently it goes through a machine which wets the nap without dampening the cloth, and is dried by hot air, which causes the nap to curl back. It is finished without shearing or pressing. Montagnac is used for overcoats.

MOUSSELINE DE LAINE. A fine, light, plain-woven worsted fabric of open texture. The name is French for wool muslin. It was originated by a man named Jourdain at Troixvilles, France, in 1826. It is made with fine, clear worsted yarns or with a cotton warp and fine worsted filling. It receives a clear worsted finish and is either printed or dyed. It is a dress fabric.

NOVELTY YARN FABRICS. There is a great variety of fancy fabrics made altogether or in part with novelty yarns, and frequently novelty yarns are used to produce nubs and spotted color effects on certain staple fabrics, such as cheviots. These yarns are made in a number of ways. Generally they are made by twisting two or more yarns into one. For instance, a coarse yarn may be twisted with a fine yarn or a colored yarn with one or more bleached yarns. The coarse yarn or the colored yarn may be delivered at intermittent speed to the spindles, with the result that it forms small loops which appear as coarse or colored nubs in the finished fabric. Sometimes the same effect is produced by using worsted filling yarns with a spiral twist, which curl up into loops or nubs when the fabric is fulled. Imitations of novelty yarns are produced also by methods of carding and spinning which result in coarse uneven woolen yarns. Frequently nubs are made from short, curly wools in the carding process, and are subsequently dyed, mixed with raw stock and spun into nubby yarns. The genuine novelty yarns, as a rule, are either all worsted or mixed worsted and cotton. Typical examples of novelty yarn fabrics are éponge and ratiné. Imitations of novelty yarn

effects are sometimes obtained by means of the terry weave (see **PILE FABRICS**).

OUTING FLANNEL. A soft, twilled, slightly napped fabric used for outing clothes. It is made from fine-spun woolen yarns or from mixed cotton and woolen yarns. It is stock-dyed, twill-woven, fulled, washed, dried, brushed up to raise a slight nap, sheared and pressed. The name is often applied to a cotton flannelette with the same surface characteristics.

PILE FABRICS. This name is used to designate a large class of fabrics in which a certain proportion of the yarns or fibers are raised from the body of the cloth so as to produce a napped or furry surface. When this is done by a napping machine in the finishing process the fabric usually is known as a napped fabric although sometimes, as in the case of velours, it is included under the heading of pile fabrics. Strictly speaking a pile fabric is one in which the pile effect is obtained in the weaving process. There are a number of different ways in which this is done. A common way is by means of a variation in the twill weave, known as the terry motion (from the French *tirer,* meaning to draw or pull). Two sets of warp threads are used, one of which is very slack. As the filling threads are beaten up by the reed in the weaving they draw the slack warp threads into loops. Sometimes the same result is obtained by inserting wires weft-wise in the cloth, over which the warp threads pass in the weaving, leaving loops when the wires are withdrawn. Fabrics produced by either of these methods are known as warp-pile fabrics. When the loops are left uncut the fabric is known as a loop-pile fabric. When they are cut the fabric is known as a cut-pile fabric. Cut-pile fabrics are made also by using an extra set of filling threads which are not carried all the way across the cloth, like the regular filling threads, but are floated to the surface at intervals and subsequently sheared to even the pile. This is known as a weft-pile. Another method of making a pile fabric is by means of the double-cloth weave. By this method two pieces are woven at the same time, face to face, and subsequently cut apart by a knife. The pile is formed by the interlacing of threads between the two

cloths. Imitations of novelty yarn fabrics, such as éponge and ratiné (q. v.) sometimes are made by means of the terry motion, above mentioned, the loops being left uncut.

POPLIN. A strong, durable fabric with fine cross-ribs, made originally with an organzine warp and woolen filling, but now made of all worsted, silk and worsted, or cotton and worsted. The average poplin is made with worsted yarns spun on the French system from medium grade crossbred wool. The rib is produced by using a larger size yarn for the filling than for the warp. All-wool poplins are piece-dyed; but silk or cotton-mixed poplins are yarn-dyed. The goods are not felted, but are scoured, crabbed, brushed, sheared, sprayed and pressed, resulting in a clear, somewhat lustrous finish.

PRUNELLA. A strong, warp-face fabric made in a satin weave, usually with a worsted face and cotton back. As a rule it comes in black and white stripes. The worsted yarns are spun from a fairly coarse, long-staple, crossbred wool of ½-blood or lower. After being woven it is scoured, crabbed, dyed, dried, brushed, sheared, sprayed and pressed. It is used chiefly for skirts and shoe tops.

RATINÉ. A rough, spongy cloth similar to éponge (q. v.). The name describes an effect rather than a fabric. The effect is obtained either by the use of novelty yarns (q. v.) or by means of the terry weave (see **PILE FABRICS**). Ratiné fabrics are used chiefly for dresses and coatings.

SERGE. The name was applied originally to a twilled worsted fabric made from medium-count, 2-ply yarns (about 32's) with a very distinct twill and a somewhat harsh feel. Nowadays the name covers almost every variety of clear-finished twilled worsteds, especially piece-dyes in navy and black. Usually it is made with a 2-ply warp and single filling, while the best grades are made with 2-ply yarns in both warp and filling. The lower grades are made with single warp and filling. All kinds of raw stock are used in serges, from low crossbred wool in the cheaper grades to fine Australian merino in the best grades. There also is a large production of cotton-warp serges. Serge is not fulled after weaving, but is

crabbed, dyed, closely sheared, sprayed and pressed. It is used for suits and dresses. Storm serge is a name applied to a light serge (about 7 ounces to the yard), made with single yarns in warp and filling, and used for women's coats.

TRICOTINE. Originally this name was applied to a fairly fine-gauge knitted fabric. Nowadays it is used to describe a fine twilled worsted fabric, with a warp-wise rib effect, obtained by groupings of two single ends with a distinct space between each group. It is made with single yarns in warp and filling.

TWEED. A somewhat rough woolen fabric similar to cheviot (q. v.). It originated in Scotland, where it was made from homespun yarns of coarse cheviot wool. Later the Scottish tweed makers began to copy the colors of the heather, bracken and grasses on the moors, and produced the heather mixtures which are characteristic of Scotch tweeds. This range of colors was enlarged by Sir John Lovat, who copied the blends of colors in the rocks of the Highlands during the hunting season (in the fall), and originated the famous Lovat shades. Tweeds are made, as a rule, from fairly coarse, medium-grade wools (usually about ¼-blood grade), and are stock-dyed. Some qualities are made from Saxony or fine Australian merino. They are woven either in a plain or twill weave, with 2-ply warp and heavy single filling or 2-ply yarns in both warp and filling. In the so-called Bannockburn tweeds the ply yarns contain two single yarns of different colors. Most tweeds are woven with checks, twills or herringbone patterns. The goods are slightly fulled after weaving, and subsequently are scoured, dried, steam-brushed, lightly shorn and pressed. Tweed is used for dresses, suits and coats.

VELOURS. A variety of woolen fabrics, all of which are characterized by a soft, velvety nap. They are included frequently under the heading of pile fabrics, although strictly they are napped fabrics. They are made, as a rule, from medium-staple fine wool of good felting quality. They are stock-dyed and plain-woven. Subsequently they are well fulled, napped (usually with a teasel gig), wet-brushed, dried, brushed, steamed, sheared, brushed again, sprayed and pressed. They are used for coats, suits and dresses.

VENETIAN. A light, strong woolen fabric with a fine, diagonal twill. It is made from various grades of wool and shoddy, with single yarns in warp and filling. Sometimes the yarns are spun from mixed colored stock and sometimes the fabric is piece-dyed in solid colors, usually black. Mixed-colored venetians frequently are sold as coverts (q. v.), but the genuine covert cloth is woven with 2-ply yarns. Venetians are fulled and slightly napped, and may be given either a clear or a face finish. Used mostly for coats and skirts.

WHIPCORD. A strong worsted fabric with round, diagonal ribs on the face. It is made, as a rule, from coarse wool of about ¼-blood, with a 2-ply warp yarn which is floated over a number of single filling yarns, thus forming the raised ribs. Sometimes these warp yarns are of a different color from the foundation yarns, and the ribs consequently differ in color from the body of the cloth. Usually, however, the cloth is yarn- or piece-dyed in solid colors. It is finished with a polishing machine, which gives it a smooth gloss, and subsequently is sheared and pressed. It is a dress fabric.

WOOL CRASH. A light, coarse, plain-woven woolen fabric made in imitation of linen crash. It is woven with rough, hard-twisted yarns spun from low-grade wool. Usually it is stock-dyed in mixed colors, but frequently it is piece-dyed. It receives very little fulling, and is finished by shearing and pressing. Wool crash is used mostly for summer suits.

WORSTED. Any fabric made from worsted yarns. The distinguishing feature of worsted yarns is that they are spun from combed wool, usually long-staple wool and receive a good deal of drawing before they are twisted. Most worsted yarns are spun on a cap frame or a ring frame machine, and are smooth, even and firm. Sometimes they are spun on a mule frame, which produces softer and more spongy yarns than the cap or ring frames. Mule-spun worsted yarns are commonly described as French-spun or spun on the French system. Worsteds differ from woolens in having a clear finish and a somewhat harder and stiffer feel. They are not fulled, like woolens, but are finished by being crabbed, closely sheared, sprayed and pressed. Sometimes they are very lightly

sheared, so as to leave a slight nap, and receive comparatively little pressing. Such fabrics are known as unfinished worsteds. Clay worsteds are made from high-grade stock spun into rather soft-twisted yarns and woven with a 6-harness twill weave, producing a very distinct round rib effect. They receive a clear finish.

ZIBELINE. A thick woolen fabric with a long, straight, flattened-down nap and a high luster. It is made with a coarse, heavy yarn, spun usually from a mixture of wool and mohair. Frequently it is woven as a double cloth, with a backing of worsted or cotton. It is fulled, scoured, wet-napped, brushed, steamed, dyed, brushed again and pressed. It is used for coats.

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